REPORT OF PROCEEDINGS

OF THE

BRITISH ASSOCIATION OF GAS MANAGERS.

1872.

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British Association of Gas Managers.

[Incorporated Gas Institute. London]

REPORT OF PROCEEDINGS

OF THE

NINTH ANNUAL MEETING,

HELD

AT THE SOCIETY OF ARTS' ROOMS,

JOHN STREET, ADELPHI, LONDON.

JUNE, 1872.

PUBLISHED FOR THE ASSOCIATION BY

W. H. BENNETT, *Hon. Sec.*,

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BRITISH

ASSOCIATION OF GAS MANAGERS.

REPORT OF PROCEEDINGS,

&c., &c.

The Ninth Annual General Meeting of the Members of this Association was held on Tuesday, Wednesday, and Thursday, the 11th, 12th, and 13th of June, in the Rooms of the Society of Arts, John Street, Adelphi, London.

TUESDAY, JUNE 11.

The President, JABEZ CHURCH, Esq., M.I.C.E., took the chair at eleven o'clock this morning.

The HONORARY SECRETARY (Mr. W. H. Bennett) read the minutes of the eighth annual meeting held last year in Dublin, which were approved.

The following list of applications for ordinary membership, which had been submitted to the committee, was then presented:—

ORDINARY MEMBERS.

Barclay, David	Tottenham.
Berry, George	Ashford.
Brett, R. W.	Hertford.
Broadberry, William Henry	Southend.
Brothers, F. W.	Calcutta.
Bryan, Eli	Sandback.
Clarke, David	Glossop.
Clarke, Richard	Truro.
Cranmer, J. S.	Malton, Yorkshire.
Crossley, Thomas C.	Guernsey.
Currie, Joseph Allan	Waltham Abbey.
Cutler, George	Whitehaven.
Daniel, Thomas Henry	Congleton.
Dixon, Charles	Horncastle.
Dougall, Archibald	Elgin.
Edson, George	Otley, near Leeds.
Eunson, John	Northampton.
Farrand, F. F.	Caterham Valley.
Gill, Joshua	Dawley, Shropshire.
Goddard, D. Ford	Ipswich.
Goldsmith, George	Leicester.
Good, Robert	Carshalton.
Green, Benjamin	Mitcham.
Grimwood, C. W.	Sudbury.
Hancock, P.	Middlewich.
Hardie, William	Newcastle.
Hegarty, John	Colombo.
Hersey, Thomas	London.
Hislop, G. R.	Paisley

Jones, C. W.	Genoa.
Jones, William J.	Malta.
Jones, W. R.	Glasgow.
King, R.	Wolverton.
Laing, Robert	London.
Lord, Edmund	Whitworth, Rochdale.
Macfarlane, J. R.	Manchester.
Markham, Thomas T.	Hull.
Medhurst, William	Folk.
Moor, W.	Hetton, Durham.
Mortis, William John	Eltham.
Mossman, Thomas	West Hartlepool.
Muriel, George	Smyrna.
Niven, George Henry	Skelmanthorpe.
Ogden, Samuel R.	New Wortley, Leeds.
Ozanne, Ernest	Guernsey.
Parsons, Matthew J.	Carnarvon.
Parsons, William	Atherstone.
Philps, Walter	Dorking.
Price, Jas.	Sutton, near Chester.
Sheppard, Robert	Horsham.
Stormouth, T.	Letterkenny.
Swallow, D.	Bradford.
Tallentire, T.	Lisburn.
Tidman, Edward	North Ormsby.
Travers, Thomas	Cork.
Valon, William A.	Ramsgate.
Watsen, James	Lower Sydenham.
Watson, Robert	Morpeth.
Watson, William Clarke	Kingston-on-Thames.
Wells, Henry J.	Tredegar.
White, William	Abersychan.
White, W.	Woolwich.
Woodward, J.	Spalding.

It was unanimously resolved—"That the gentlemen whose names have now been read be elected ordinary members of the association."

The Honorary Secretary read the names of the following gentlemen who had applied to be admitted extra-ordinary members of the association:—

EXTRA-ORDINARY MEMBERS.

Aird, Joseph	Great Bridge.
Andrews, W. W.	London.
Braddock, Joseph	Oldham.
M'Dougall, jun., Alexander	Manchester.
M'Dougall, James Thomas	London.
Manwaring, Joseph	London.
Peebles, D. Bruce	Edinburgh.
Willey, Henry Frederick	Exeter.

These gentlemen were unanimously elected extra-ordinary members.

Messrs. Eldridge and Plumbe were appointed scrutineers of the votes for the election of committee and officers for the ensuing year.

The President delivered the following

Inaugural Address.

Having done me the honour to elect me president of the British Association of Gas Managers, I now, with much pleasure, enter upon the duty which precedent has attached to that position—that of addressing you from the chair; and in doing this permit me, first, to assure you that I highly esteem the honour you have conferred upon me, although at the same time I feel some little diffidence in addressing you upon the present occasion. This arises in part from the knowledge that I stand in the presence of so many fellow-members, brethren in the profession, who are my seniors; but I am

reassured when I reflect that we are assembled here with the common object of imparting and receiving instructive information upon those subjects which are to us, individually and collectively, of the highest interest and of the first importance. Moreover, I am convinced that I express the sentiments of all present when I say that but one feeling pervades us, and that is a sincere desire, without bias or reserve, mutually to assist and inform each other, by an interchange of our varied experiences in the scientific and mechanical details connected with the manufacture and distribution of gas. Firm in this conviction, I am emboldened in my attempt to place before you my views and experiences, although they may possibly prove in some respects comparatively crude and contracted when compared with those of many riper and more matured minds now amongst us. Nevertheless, such as they are, I venture to bring them under your notice, trusting your consideration will cover my deficiencies, and will render my observations acceptable.

Any feeling of anxiety or responsibility I may naturally experience in assuming the general duties of the presidential chair is relieved by the knowledge that I may rely upon the hearty co-operation of every member of this association in carrying out those duties. In a word, gentlemen, to you I look for support and assistance in order that we may conduct this conference to a successful issue. I am satisfied that I shall not ask in vain, nor will you deny me another boon—that of your indulgence for any shortcomings I may manifest in the conduct of our proceedings.

It is a source of great satisfaction to me to be able to state that the British Association of Gas Managers has proved to be a thoroughly successful undertaking. I am happy to inform you that its present position is almost all that could be desired, and cannot but be highly gratifying to those gentlemen who, but nine years since, united with a view of establishing it. Although we have only been established so short a time, our members number very nearly 400, and we have to our credit a cash balance of more than £300. The progress of our society has proved as useful as it has been rapid, and we may now consider it as a permanent institution. Looking to the future, I see every reason to hope for a continuance, and even an increase, of its prosperity. By the addition of every new member, the sphere of its usefulness becomes widened and its practical value increased, and as we are constantly receiving accessions to our members, so are we the more firmly consolidating our position, and commanding recognition, not only throughout the kingdom, but in every part of the world where the subject of gas lighting is entertained.

During our present session some very valuable papers will be read, some of which have been contributed by gentlemen who are well known for their skill and ability in those departments of gas engineering to which they direct their special attention. No doubt much valuable information will arise from the reading of these papers, and much practical knowledge will be gained from the discussions which will follow thereon.

It is of the greatest importance to the success of this association that every member should contribute, as far as he is able, information in this form.

Unquestionably our success and status as an associated body are closely identified with, and largely due to, the reading of sound practical papers.

The aim in preparing papers should not necessarily be length, for it frequently happens that short papers are much better than long ones. It behoves every member to exercise both care and judgment in the preparation of a paper, but the more concise it can be practically made the better.

With a view of stimulating members to produce meritorious papers, I think we should do well to offer premiums to those who benefit the association by such productions. Our funds are sufficient for the purpose, and I therefore suggest the propriety of offering premiums for papers to be read at future conferences. This practice has been most successfully adopted by societies of a kindred character and cannot fail to be beneficial to us.

I am happy to inform you that considerable attention has been paid by members of this association to the reduction of Sunday labour, and that the result, in many cases, has been of the greatest possible benefit to workmen. In all the London gas-works the hours of labour have been greatly reduced. Mr. George Livesey, Mr. Robert Morton, and others, have stopped their works en-

tirely for twelve hours on Sundays during the past winter. This practice has not been confined to London, but has extended in a great many instances to works in the country, where a cessation of labour during a like number of hours has taken place. I need not urge upon you the importance of extending this good work, feeling assured that every member will forward and promote this great desideratum to the fullest extent that the particular circumstances of the works in which he is engaged will admit.

Passing from the interests of the workman to those of the manager, I cannot allow this opportunity to escape without reintroducing the subject of raising a benevolent fund for the relief of incapacitated deserving managers, or those who, dying, may leave behind them a family needing assistance. This subject was forcibly brought before you by our past president, Mr. Barlow, in 1868, at which time he kindly stated that if such a fund were established, he would substantially contribute towards it. Last year the question was again brought under your notice, but unfortunately no further progress was made. I therefore feel some diffidence in again drawing attention to this subject, but to my mind it is of great importance, and is well worthy of your immediate practical consideration. I am also much encouraged in bringing this before you as a gentleman who takes great interest in the success of our association has offered to contribute the munificent sum of £100 towards the establishment of such a fund. It is my friend Mr. A. A. Croll to whom I refer; and from conversation I have had with other members I feel assured that a sum of money could be at once raised for the purpose, which would form a substantial nucleus to be increased from time to time. We should thus possess a fund which would prove of essential value in assisting those of our members who may have the misfortune, either from accident or incapacity, to require such aid. It is for you, therefore, either to refuse the offers thus made both by Mr. Barlow and Mr. Croll, or to determine that such a fund shall be forthwith raised, and to request the committee to take such steps as may be necessary for its establishment, and frame such rules as may be requisite for its management and application.

It is my painful duty to inform you that since we last met several of our friends and fellow-workers have passed away. Amongst them are three leading men in the profession, whose names can only be mentioned with a regret equal to the respect in which their memories are held. In August last we lost Mr. John Kirkham (father to our vice-president, Mr. T. N. Kirkham, and late engineer to the Imperial Gas Company), who might fairly be classed as one of the pioneers of gas lighting. He was a man of considerable engineering ability, and has left some noble monuments of constructive skill at the works over which for many years he was the chief. He was not only esteemed for his professional knowledge but for kindliness of heart and gentlemanly bearing to all with whom he was associated. He died at the age of 79, and was deservedly esteemed and respected by every member of the profession who had the good fortune to know him.

The next deceased friend of whom I have to speak was perhaps better known to you. This was Mr. Thomas Livesey, late secretary to the South Metropolitan Gas Company, and father to our esteemed vice-president, Mr. G. T. Livesey. He was elected president of this association in June, 1870. It will be within your recollection that through the delicate state of his health, he was incapacitated from taking even a short sea voyage, and we, therefore, had to forego the valuable services that he would have rendered us, had he been enabled to preside at our Dublin conference. He was a man of an eminently practical nature, of great perseverance, and of the most rigid integrity; in fact, he may be classed with the George Stephenson type of men. He was the architect of his own fortune, and in every particular a most successful man. He died very suddenly in October last, being in his 65th year. At the age of 15 he entered the service of the Chartered Gas Company as a clerk, remaining there for 18 years, after which, in the year 1839, he was appointed chief clerk to the South Metropolitan Company, eventually becoming secretary on the incorporation of the company in the year 1842. At that time the capital of the company was £88,000, and the gasholder capacity was 144,000 cubic feet, and the price charged for gas was 10s. per 1000. The company was then in an almost ruinous condition, but by his steady perseverance, quick and clear perceptive

power, and businesslike habits, Mr. Livesey raised the undertaking to a state of the highest prosperity. At the time of his death the capital was £300,000, with a reserve-fund amounting to £46,000, the gasholder storeage was 2,400,000 cubic feet, and the selling price of gas was 3s. 2d. per 1000 feet. This complete metamorphosis was made during the 32 years that our departed friend was in the service of the South Metropolitan Company, which is without doubt at the present moment the most prosperous gas company in the United Kingdom. In his private life he was most kind, and nothing that could be said in his favour would be beyond what his sterling character and honesty of purpose justly merit.

In February last we lost Mr. John Grafton, who formerly held a high position in gas engineering, but of late years has lived apart from professional pursuits. In 1814 he was one of Mr. Samuel Clegg's pupils, and he continued with him for some time. To him we are indebted for the introduction of brick ovens and clay retorts, as well as for the introduction of the exhauster. Mr. Grafton erected a large number of works in this country, and at one time was the sole proprietor of the Cambridge Gas-Works. He was also concerned as director and shareholder in a number of other companies.

The legislative proceedings affecting gas companies have, during the past year been of a troublesome character, and were instituted in a manner most prejudicial to the interests of such companies.

The first was "The Gas-Works Clauses Act, 1847, Amendment Bill (No. 2)." This bill, which was introduced by the Board of Trade, created great surprise in the gas world, as no notification of any intention had been previously given of amending the original Act of 1847. As this Act had worked satisfactorily, both to the consumers and gas companies, it did not appear that any further legislation was necessary. The bill, as first introduced, was highly objectionable, and most detrimental to the value of gas property. It was fortunately opposed on the second reading, and a number of gas companies, both incorporated and unincorporated, lost no time in petitioning against it, and mainly through the instrumentality of the Gas and Water Companies Association, the result arrived at was the amendment of some, and the withdrawal of other, objectionable clauses. The bill has now passed into law, but without doing us material damage, although there are still some clauses retained which are not of a desirable character. On the whole, however, there is cause for congratulation that the companies succeeded so well in their opposition to so unjust a bill.

Another bill has also been introduced into the House of Commons by Messrs. Leeman, Mundella, Goldney, Candlish, and Dodds, entitled, "The Municipal Corporations (Borough Funds) Bill." Its object is to authorize the application of funds of municipal corporations, and other governing bodies, in certain cases, such as in opposing gas and water companies bills in Parliament. It is a bill fraught with much danger to gas companies, and no doubt its introduction arose out of the case of *Roberts v. The Corporation of Sheffield*, in which the Court of Queen's Bench ruled that corporations have no power to expend money out of their rates in prosecuting gas and water companies bills. It was then referred to a select committee, consisting of 21 members. A large number of petitions were presented by gas companies against this bill, and Mr. Baxter was retained by the Gas and Water Companies Association, and appeared before the select committee on their behalf to oppose it. It was consequently amended, and is now very much altered, though not to the extent that the companies could have wished; nevertheless, the alterations are all in favour of the companies, and in its present shape it is unquestionably of a much less objectionable character than when first introduced. What further amendments it may be subject to will depend upon the decision of the House of Lords.

"The Gas and Water Facilities Bill" of last session has been brought into operation by several companies, and appears to be of much value when the application of a company is unopposed. The expenses of statutory power under its operation are less costly than in the case of a private bill.

The metropolitan gas referees, appointed by the Board of Trade, have during the past year issued three reports—the first on the ammonia impurity in gas, the second on the construction of gas-burners with regard to the principles of gas illumination, and the third on sulphur purification at the Beckton Gas-Works. In the report on burners a great deal of useful information is given, but no new facts are set forth therein that can claim our attention. All the experiments made

and their results, in using good and bad burners, have been long known to the members of our profession who are conversant with the subject of gas-burners and the necessity of having a properly adjusted supply of atmospheric air. The referees, however, having promised a further report on the subject, we may hope to receive not only some practical suggestions on the defective constructions of the burners now in use, but also remedies which will overcome their admitted defects.

The report on ammonia impurities contains some practical facts and suggestions, and will prove valuable to the profession. When the referees were first appointed they fixed 5 grains of ammonia per 100 feet of gas as a maximum, and from the experiments they have made, and also from the actual working of some of the metropolitan companies, they find it practical to manufacture gas quite free from ammonia. They consequently gave notice to the companies that on and after the 1st of November of last year, the maximum quantity of ammonia allowed in the gas was to be reduced from 5 grains to 2½ grains, and they now further hint that the standard will be reduced to *nil* ere long. They state that the process of purifying gas from ammonia consists mainly in bringing the gas into contact with water, which has a remarkable affinity for it, and is capable of absorbing above 700 times its own volume, and the most perfect process of ammonia purification is that which does its work with the least amount of water. The reasons given are—first, because when much water is used it absorbs a portion of the hydrocarbons; second, because the ammonia so formed is too weak to be saleable; and, third, that in consequence of this, the liquor has to be returned and passed through the scrubber several times to bring it up to the required strength, whereby the impurities with which the water is charged are again brought in contact and absorbed by the gas. The referees after setting forth the absolute necessity of proper and efficient condensing power, make special mention of the scrubbers employed at Blackfriars, as being the nearest to perfection in their operation. In Table 3 of their report they show the amount of ammoniacal liquor obtained per ton of coal in the different gas-works, and as at the Blackfriars works the whole of the ammonia is taken out of the gas, and also is eliminated almost entirely by the scrubbers in the form of ammoniacal liquor, the actual amount of ammonia may be calculated. At these works, 20 gallons of ammoniacal liquor of 10 oz. strength are obtained from each ton of coal, showing that the gas from each ton of coal contains about 1-10th of 1 per cent. of ammonia gas (NH_3). In other words, there is 1 foot of NH_3 in every 1000 feet of gas.

A considerable proportion of the ammonia is eliminated from the gas in the condensing pipes before reaching the scrubbers, and the more efficient the condensing process, the more easily is the work of ammonia purification carried on in the scrubbers. At the Blackfriars works the condensers yield per ton of coal about nine gallons of 6 oz. liquor, and the scrubbers yield eleven gallons of 14 oz. strength, so that in this case one-third of the ammonia is taken out by the condensers and two-thirds by the scrubbers. But the ammoniacal liquor obtained from the condensers is too weak to be saleable, hence it has to be mixed with the stronger liquor obtained from the scrubbers. The requisite commercial strength of the liquor is about 10 oz.; if the liquor is much below that strength it is objectionable from its bulk, whilst if it is much above that strength it is objectionable as a saleable commodity, owing to its tendency to lose a portion of its ammonia by volatilization.

The "liquor" obtained from the condensers varies in strength from about 4½ to 7 oz.—these variations being mainly due to the condition of the coal as delivered to the retorts; for the drier the coal the less aqueous vapour is contained in the gas. Accordingly, the ammoniacal liquor formed in the condensers is less diluted than when the coal is more or less damp.

The ammonia which remains in the gas after passing through the scrubbers at the Blackfriars works only amounts to 2 or 3 grains per 1000 feet of gas. This residue is entirely absorbed by the moisture contained in the oxide of iron purifiers employed for the elimination of sulphur. At the same time it is to be observed that, in proportion as the amount of ammonia in the gas is reduced, the difficulty of catching it in the scrubbers becomes immensely increased. For example, in the excellent scrubbers employed at the Blackfriars works, where the coke is divided into three tiers or compartments, each 8 feet in depth, it is found that the lowest tier, which the gas first enters, yields of itself 11½ oz. liquor, the middle tier 2 oz. liquor, and the uppermost tier only

½ oz. liquor. In other words, of the total amount of ammonia eliminated by this scrubber (which yields 14 oz. liquor), the uppermost tier takes out only 8½ per cent., while the lowermost takes out 82 per cent. Arguing from such facts, it is a common opinion in gas-works that the more the water is impregnated with ammonia the more capable is it of absorbing ammonia—a notion, it is hardly necessary to say, wholly erroneous. The explanation of the fact, which has given rise to this idea, is evidently the very simple one, that the difficulty of catching ammonia (or any other substance) is immensely increased when the ammonia is greatly diluted, or, in other words, exists only in an infinitesimal quantity, compared with the volume of gas in which it is contained; whereas, when the water or liquor comes in contact with the unpurified gas, as it does in the lower part of the scrubber, the proportion of ammonia absorbed is very large.

A report on the sulphur purification at the Beckton Gas-Works, dated January 31, 1872, has been issued, the publication of which was looked forward to with much interest, especially as the Gas Committee of the Corporation of the City of London has loudly complained of the large increase in the amount of sulphur in the gas supplied to the City since its manufacture commenced at the Beckton works. It appears from the report that the complaints made by the Gas Committee were well founded, inasmuch as the sulphur compounds in the gas supplied by the Chartered Company previously to the opening of their new works at Beckton contained, on the average, 27·1 grains in 100 cubic feet, whereas the gas from Beckton in the middle of last year contained, on the average, 43·2 grains, and even this large amount has been increased since that time.

The report is voluminous, and bears evidence that great care, attention, and industry have been bestowed in the consideration of this important subject, not only by the referees themselves, but also by the officers of the companies, who have given the referees the benefit of their skill and experience, in order to assist in solving a most difficult problem. In the report it is most clearly and distinctly stated that the inquiry relates exclusively to that portion of sulphur in gas which exists in other forms than that of sulphuretted hydrogen, as the referees have never found a trace of sulphuretted hydrogen in the gas supplied to the public, although the testing to which it has been daily subjected has been exceedingly stringent. The referees give the highest credit to the engineer-in-chief of the company, for having spared no expense with a view to ensure the completeness and efficiency of the works, and for having provided apparatus on an unusually extensive scale for sulphur purification, the magnitude and number of the purifiers relative to the make of gas being greater than in those employed in any other gas-works in the kingdom. It was, therefore, hoped that the hitherto unsurmounted difficulty with regard to sulphur purification would be at an end. Unfortunately, however, the result has not only fallen short of these expectations, but has proved a most startling and utter failure.

A complete table, *inter alia*, is given, showing the comparative superficial area of the purifiers per 1000 feet of gas made hourly at the several metropolitan works. Commencing with Beckton works, we find them to have 47·1 square feet, the Westminster, 31·18; Blackfriars, 25·3; Bow Common, 37·7; Fulham, 28·4; St. Pancras, 24·3; Haggerston, 21·1; and the South Metropolitan, 25·5. Taking the Haggerstone works as the unit of comparison 1, St Pancras is 1·15; South Metropolitan, 1·2; Blackfriars, 1·2; Fulham, 1·34; Westminster, 1·47; Bow Common, 1·78; and Beckton, 2·2. Thus the extent of purifying power, relative to the make of gas, at Beckton is more than double that of Haggerston, and nearly double that of most of the other gas-works except that at Bow Common.

The purifying materials used were lime and oxide of iron. At first there were twelve purifiers in use, four containing lime and eight oxide, each in a single layer 2 feet thick. Subsequently the plan was altered, when eight purifiers were used with lime (before the oxide) and four with oxide. The results were remarkable for some time: the sulphur fell to an average of 15 grains but, unfortunately, and equally unexpectedly, the sulphur again increased in quantity, and became as great as before.

In another table furnished in the referees report, a comparison is given between the Beckton and Bow Common works, as to the purifying arrangements, which shows that the contents of the lime purifiers, relative to the

make of gas, are more than twice as great at Beckton as they are at Bow, and that the contents of the oxide purifiers at Bow, relative to the make of gas, are more than twice as great as they are at Beckton.

In another table we are also shown that relatively to every 1000 cubic feet purified at Beckton, the quantity of lime in constant action is about 2½ times greater than at Bow, and moreover of this quantity of lime in constant action, the proportion of clean lime used per day is one-half greater at Beckton than it is at Bow Common relatively to the make of gas. The several results show, that of the gas made by all the metropolitan companies, that made at Beckton contains the largest amount of sulphur compounds, other than sulphuretted hydrogen, and that the gas made at Bow Common contains the least.

In the second part of the report the referees promise a further report on this most important question, and express a determination to investigate the question of impurities to the utmost extent, and to overcome existing difficulties. In referring to the failure of purifying gas from sulphur compounds, the referees suggest that it may be classed under two heads—first, probably from some defect in the distillatory process, whereby an unusual amount of sulphur, other than sulphuretted hydrogen, is produced in the gas; and, secondly, the almost total failure of the process of purification as regards this particular impurity. The referees do not consider the failure arises from the construction of the purifiers or the mode of working them, but they attribute it to the antecedent processes of gas purification by defective condensing power, besides which they state carbonic acid to form an important, and hitherto unsuspected, element of the failure.

They have previously pointed out that if gas is not properly cooled in the condensers before leaving the scrubbers, the absorbent power of the liquor in those vessels is diminished, while if tarry vapour in large quantity is carried forward into the scrubbers, the scrubbing material may be suddenly fouled, and to a degree which seriously affects the purifying action of the apparatus. In this statement—as now appears to the referees—lies the key to the secret which has hitherto escaped detection at the Beckton works. The inadequacy of the condensing power has hitherto impaired the action of the scrubbers, and this in turn has impaired, or almost neutralized, the action of the lime in the purifiers upon the sulphur.

With the requisite condensing power the function of the scrubber is to free the gas from ammonia, but in addition to this it also eliminates a considerable portion of sulphuretted hydrogen and carbonic acid contained in the gas, and hence its importance, for if any portion of the carbonic acid be not taken out by the scrubbers, it necessarily goes forward with the gas into the purifiers, and in the case of lime purifiers the entrance of carbonic acid is of all things the most detrimental to their action, as it converts the lime into carbonate of lime, which has no effect whatever upon the sulphur compounds contained in the gas. However large or numerous the purifying vessels may be, when the lime is in a state of carbonate they are perfectly useless. It is only when the lime exists as sulphide of calcium that it acts upon sulphur; therefore, in the opinion of the referees, the excess of carbonate in the lime purifiers is unquestionably the true cause of failure in this branch of the purification at Beckton. The facts set forth by the gas referees are incontrovertible, and it now remains for us to devise a method to overcome this difficulty, as it must of necessity be surmounted, however great the task may be. The referees state that they feel assured that perfect results would be obtainable from the lime process, if carbonic acid were excluded from the purifiers, and also that the results will be adequate to the requirements of the public, if the carbonic acid which enters the purifiers be kept down to the lowest point actually obtainable in gas-works.

The problem, therefore, to be solved is to devise some method of taking out all the carbonic acid from the gas during its manufacture without simultaneously taking out all the sulphuretted hydrogen, which latter compound is needed to convert the contents of the purifier into sulphide of calcium; and the essence of the difficulty consists in the fact that carbonic acid exists in the gas in very much larger proportion than sulphuretted hydrogen, whilst, at the same time, there is not a chemical substance yet discovered which will absorb carbonic acid without also absorbing sulphuretted hydrogen.

In reviewing the various inventions introduced during the past year bearing directly on gas-lighting, I will direct your attention, in the first place, to per-

haps the most important—viz., Dr. Eveleigh's patented improvements in the manufacture of gas. The invention relates to the manufacture and purification of gas generated from common coal and other similar substances.

The special improvements consist in distilling from these substances, in a retort at a comparatively low temperature of about 600° to 1000° Fahr., the best and richest portions of the gas contained in such substances, together with the oleaginous, tarry, and other vaporizable matters, the residue which remains in the retort being coke of a superior quality. The rich gases, together with the vaporizable matters, are conducted from the retort by pipes in a manner somewhat similar to that followed in ordinary practice; instead, however, of the usual hydraulic main, Dr. Eveleigh uses a large evolving tank, in which the chief portions of the oily and other vaporizable matters which come over with the gas are condensed as quickly as possible. The rich gas passes on into a peculiar cooler and condenser of the following character:—A large covered tank, about half filled with water, receives the gas from the pipe leading from the first-named cooling-tank. The gas coming in contact with the extended surface of water, is still further freed from depositable substances, and when thus freed becomes lighter, rises to the top of the tank, and passes off at the opposite end by a pipe the mouth of which rises nearly to the top of the tank. This gas is then further cooled, if necessary, by being passed through pipes immersed in water. From thence it is led to the purifiers. The larger proportion of the oleaginous and other vapours which are condensed in the first cooling-tank, and the remainder which is deposited in the second cooling-tank and condenser, are then collected and conveyed into another tank, from which they are allowed to flow gradually into a heated pan, where they are revaporized, and from whence the vapours so reproduced are passed through redistillation retorts charged with chemical purifiers. In the redistillation retorts the vapours are converted into gas, which is purified therein. From the redistillation retorts the gas is passed through a cooling-tank similar to that already mentioned, and which contains water, wherein any of the vapours which have not been converted into gas by their passage through the redistillation retorts are again condensed, and may be returned to the revaporizing pan and redistillation retorts for further treatment. This process is repeated over and over again until the whole is decomposed, or until only *pitch* remains. From the cooling-tank this gas passes on to the condenser before referred to, mixing on its way with the rich gases coming over direct from the first distilling retort, and passing on with them to the purifiers, and thence to the gasholder for use.

By this process the patentee states that he is enabled to employ a low temperature in order to obtain the best and richest portions of the gas from the coal, and by his treatment of the oily, tarry, and other gas-producing vapours, he states that he fully utilizes them, and obtains the remainder of the gas which they contain. In most cases, by these means, he finds that he not only produces a larger total quantity of gas from a given quantity of coal, but the illuminating power and purity of the gas so produced are much greater than can be obtained by the ordinary process, in which a great heat is employed. The value of the residual products, such as the coke and pitch, is also said to be greatly increased.

In order to give effect to the practical working of this process, the Patent Gas Company have erected distillatory apparatus at the New Barnet Gas Company's works, and have been manufacturing all the gas required by that company for the supply of their district for some months past. They have proved conclusively that they can manufacture gas from common coal of 20-candle power; but upon the cost of manufacture and other important commercial points we are not yet informed.

Another invention, called the "Oxyhydric Light," has created some sensation, and has been publicly exhibited at the Crystal Palace during the past season. The principle is by no means new, and consists in the introduction of oxygen gas at the point of combustion with common gas. Originally, when the system of using oxygen and coal gas together was introduced, it was known as the lime light, being much admired for its brilliancy and purity. Its combustion was, however, uncertain, and the cost of manufacturing oxygen was too expensive, and it therefore fell into disuse.

The oxygen used by the proprietors of the oxyhydric light is produced by the method patented by M. Tessie du Motay, the invention being based upon

the following data:—Manganates and permanganates of potassa, soda, and baryta; ferrates of potassa, soda, and baryta; chromates of potassa, soda, and baryta, and in general all metallic oxides or acids which will form with potassa, soda, and baryta, binary combinations capable of superoxidizing, and possess the property of yielding their oxygen at certain temperatures when they are submitted to the action of a current of steam. These bodies thus deoxidized also possess the property of becoming reoxidized when they are exposed to the action of a current of air. The invention, therefore, consists in the direct production of oxygen by means of atmospheric gas, and is based upon the double property just stated. In a retort one of the binary compounds is placed either at the minimum or at the maximum state of oxidation. If the binary compound is at the minimum state of oxidation, it is superoxidized by means of a current of air. If the compound is at the maximum state of oxidation, it is deoxidized by means of a current of steam. The oxygen and the steam on issuing from the retort pass together into a condenser, the steam is condensed, and the oxygen passes on to a gasholder in which it is collected. When all the utilizable oxygen contained in the binary compound has been disengaged by the action of the steam, the operation of superoxidation by means of air is recommenced, and *vice versâ*. The production of oxygen is continued in this alternate manner as long as is necessary.

The manufacture of oxygen by this process, possesses great scientific merit, the old method being entirely superseded, and the cost of manufacture greatly reduced. Upon this improvement the proprietors consider it can compete commercially with ordinary gas; they also claim other important advantages in its combustion and purity. By way of comparison, the value of the new and the ordinary system is given as follows:—

Oxyhydric.	s.	d.
2000 cubic feet coal gas at 3s. 9d. per 1000	7	6
Carburetting the same at 8d.	1	4
1140 cubic feet of oxygen at 8s.	9	1½
	17	11½

This, it is stated, will give an amount of light equal to 10,000 cubic feet of coal gas, costing, at 3s. 9d. per 1000, £1 17s. 6d.

The comparative cost, therefore, as stated by the inventor, to produce an equal amount of light will be in each case—

By coal gas at present supplied	£1	17	6
By oxyhydric light	0	17	11½

Thus showing a saving in favour of the new supply of over 50 per cent.

The introduction of this system would involve duplicate mains, meters, internal pipes and fittings, together with apparatus for carburetting the coal gas, all of which would entail an additional expenditure. Judging, therefore, from these circumstances, it is not likely to supersede the existing system for general purposes, although it may be used for street lighting, and also in special cases with advantage.

It was exhibited in the Paris Exhibition, 1867, after which one of the Boulevards was lighted with it, but from some cause it was discontinued, and nothing more was heard of the invention until it was tried at the Crystal Palace last November.

The subject of charging and drawing retorts by machinery has been frequently brought before you, and has resulted in some very interesting and instructive discussions. I am happy to find that Mr. Somerville, who has certainly had great practical experience in the matter, has patented some very important improvements in this class of machinery. One of the chief objections to the introduction of drawing and charging by steam power has been its inapplicability, as previously designed, to existing settings. This difficulty, I am informed, has been overcome by Mr. Somerville, the machine being so arranged as to admit of such an adjustment as to make it suitable for any form of setting. Besides this, it is said to possess the additional advantages of simplicity, and freedom from excessive wear and tear, and is so contrived as to offer great facility for repair or renewal of any of the working parts. The merits of this invention, however, you will be better able to understand upon inspecting the model which is placed upon the table before you.

Mr. Somerville has also invented a retort-lid which, while it is suited for any form of mouthpiece, admits of being luted by a machine which he has constructed for that purpose, and which may be attached to the same platform as the charging and drawing machine, and driven by the same engine.

Another matter of interest, and one which is now attracting some attention, is the invention of Messrs. Porter and Lane, by which it is proposed to supersede manual labour in charging the retorts. This is effected—to use the inventors own words—"by causing the continuous passage of a thin layer of coal through a vertical retort in close contact with the whole of the inner surface thereof, leaving the interior space free for the evolution and passage of the gas. This is accomplished by means of a screw of peculiar form suspended on a central spindle throughout the whole length of the retort, which screw is driven by steam power, and feeds itself from a hopper on the top, at the same time discharging the exhausted coke into a receptacle below, when it is removed by trucks, so that the coal is untouched by hand from first to last."

The advantages are said to be economy in space, fuel, and labour, together with an increased yield and greater freedom from sulphur. This method of carbonizing has been tried experimentally on a small scale, and the results have induced the process to be looked upon with favour by some of our best practical gas engineers. I am informed that the invention is about to be tested upon a more extended scale at the works of the Chartered Gas Company. As I have not witnessed the experiments myself, I should not feel justified in offering an opinion upon the merits of this system.

It will be remembered that at our last meeting Mr. Somerville, in the course of his paper, "On the Cause and Prevention of Choked Ascension-Pipes," stated that if "ascension-pipes were cast double, or having a jacket surrounding them with a constant circulation of water or air from top to bottom, stopped pipes would be unknown."

Now, it appears that this idea had also occurred to one of our Transatlantic brethren, who, it is said, had been impressed with the notion some time previously, and by a curious coincidence had matured his plan sufficiently to be in a position to make an application for a patent on the very day that Mr. Somerville addressed us at Dublin. The patent, however, bears the subsequent date of November the 28th, 1871.

The mention of this subject naturally leads me to draw your attention to another invention, a model of which is now before you, and which has for its object also the prevention of choked ascension-pipes, or, in the event of their becoming choked, affording ready means for the removal of the obstruction. This the inventor, Mr. Box, proposes to do by making the ascension-pipe of comparatively thin wrought-iron tubing, which he believes will be far less likely to become heated to such a degree as to convert the tar into pitch than it would if made of cast iron of the ordinary thickness. Should this pipe, however, become choked through any unforeseen cause, an arrangement is provided for removing the offending pipe, and replacing it by another in a remarkably short time, leaving the foul pipe to be cleaned out at leisure.

Messrs. Fenner and Versinoun have lately patented an invention for manufacturing anthracene, samples of which are on the table for your inspection. Anthracene is a solid chemical compound made from the tarry residuum of the manufacture of gas, and since the discovery was made about three years ago that it might be converted into alizarene—which is the colouring principle of madder—it has become a highly important article of commerce. Up to the present time the supply of anthracene has been limited, owing to the means of its production being limited. It has hitherto been obtained only in the distillation of gas tar, when it passes over with the least fraction of the oil, and from which it is afterwards separated. By the new process, as stated by the patentees, anthracene may be obtained by distilling coal tar pitch, which yields about 2 per cent., or one ton, of anthracene from 50 tons of pitch. This article is in great demand, and its present market value is about £400 per ton; therefore, we may look upon this invention as an important branch of industry, which will increase the value of one of our residual products.

Another invention of considerable importance in street lighting has been introduced by Mr. Skelton, who has invented and patented a new description of lamp for street lighting. The principle of the invention is the application of reflectors, in order to bend down and utilize the amount of light which is at present wasted by upward radiation. It is manifest that the rays of light from a street lamp which now strike the eye of a spectator placed on the ground, are only a small portion of those actually emitted by the flame. The rays which pass through the upper portions of the sides of the lantern, or through its sloping roof, are entirely dissipated, or, at the best—when partially and imperfectly reflected by clouds or atmospheric particles—become visible only in the form of the lurid glare which overhangs a distant town. Mr. Skelton estimates that about two-thirds of the light given by the gas-flames are lost in this way, and he has arranged strips of silvered glass in such a manner that the loss will be effectually prevented. The upper half of each side of the lamp, and the whole of each side of the sloping roof, are occupied by a frame, in which the strips are placed, with their reflecting surfaces downwards, in a manner somewhat analogous to the laths of a Venetian blind. The precise character of the effect produced will depend upon the distance of the strips apart, upon their width, and upon their angle of inclination; but the general result is—subject to small variations—that the street receives three times as much light as would fall upon it through lanterns of the ordinary kind. The frames holding the strips are glazed on both sides, and made dust proof, so that the mirrors will not themselves become soiled or tarnished, and the reflector, as a whole, can be cleaned in the ordinary way, by simply wiping the glass. This plan has been most successfully applied to the lighting of Waterloo Bridge. It is a very great improvement, and in no department of gas lighting are improvements in this direction more needed.

Our coal supply, both present and future, must next claim our most serious attention. A report from the Royal Commission appointed to consider the subject has lately been issued, in which they assume 4000 feet as the limit of practicable depth in working, making allowance for waste and loss. This gives the quantity of coal still lying available beneath the surface of the United Kingdom as 90,207,285,398 tons—that is to say, considerably more than 90,000 millions of tons. This is exclusive of beds less than a foot in thickness. The hypothetical coal-beds of the south of England are also excluded from the calculation. But the estimate lies within still narrower limits, seeing that it is confined to areas within which the coal-bearing strata are at the surface, or have been proved by mining operations to underlie more recent formations. Geological principles lead to the conclusion that large tracts of coal exist under the Permian, new red sandstone, and other superincumbent strata, in districts where the fact has not yet been demonstrated by actual exploration. If these unexplored coal-beds are taken into account, they add 56,273 million tons to our reckoning, constituting a total of more than 146,000 millions of tons. If we extend the depth beyond 4000 feet, we get still more; but, for the present, we leave that out of the account. Let us see, therefore, how long the 146,480 millions of tons will be likely to last. In 1869 the quantity of coal raised in the United Kingdom exceeded 107 millions of tons. Professor Jevons, in his work on "The Coal Question," which appeared in 1865, estimated that the rate of growth, in the aggregate annual consumption of coal, amounted to about 3½ per cent., reckoning each per centage on the previous year's consumption. On this basis, he reckoned that the consumption in 1871 would be nearly 118 millions of tons. So far as can now be computed, the quantity of coal raised in the United Kingdom during last year was about 115 millions. Professor Jevons further showed that, at his computed rate, the coal raised in the United Kingdom would amount to no less than 2607 millions of tons at the end of a century. Upon this assumed rate of increase the whole quantity of coal reported available by the commission would be exhausted in 110 years. While it is admitted that Professor Jevons's theory has up to this time nearly accorded with observation, the commissioners object to the supposition that the annual per centage of increase in the consumption of coal will continue unabated for any considerable period. Mr. Price Williams, who has given great attention to questions of this kind, and who has been employed by the commissioners in matters of calculation, lays stress on the fact that, although the population of the United Kingdom is rapidly increasing, yet the rate of the

increase is diminishing. This is a principle which Professor Jevons has not recognized, and when it is applied in correction of his theory, the duration of the coal supply is extended to a period of 360 years, the estimated population of Great Britain at the end of that period being 131,700,000. The commissioners also give a calculation based on an arithmetical instead of a geometrical increase in the rate of the consumption of coal, simply adding a constant quantity equal to the average annual increase of the last 14 years, taking that at 3,000,000 tons. Upon this basis the consumption of coal a hundred years hence will have risen to 415 millions of tons per annum, and our available supply would then be exhausted in 276 years, a period considerably shorter than that allowed by Mr. Williams, who, while taking a geometrical ratio also, reckoned that it would be a decreasing one. There is yet another view, which the commissioners regard as the extreme opposite to that of Professor Jevons. It is that from this time forward the population, of the whole country, and the consumption of coal per head of the population will remain constant, or will merely oscillate without advancing. Taking, therefore, the present consumption of 115 millions of tons per annum, the supply would be exhausted in 1273 years. This may be called the full length of our tether, and it is certain that we should feel an inconvenient tightness long before the end was reached.

Supposing that coal could be worked at a greater depth than 4000 feet—and the main difficulty is that of the very high temperature met with at such a depth—we might add 48,465 millions of tons to our store, including the quantity believed to exist beneath the Permian formation. Assuming the whole to become available, the 360 years allowed by Mr. Williams would be increased to 433; the 276 years based on the arithmetical ratio would become 324 years, and the 1273 years based on the theory of a stationary consumption would be lengthened to 1695 years. As the commissions observe, the whole question is subject to contingencies which cannot be foreseen, and every calculation involves something speculative. What science may do for us we cannot say but clearly our coal supply is by no means inexhaustible.

Unfortunately our present supply of coal causes us far greater anxiety than anything that may hereafter happen from the exhaustion of the coal itself. We have abundance of good coal workable at controllable depths, but owing to the perversity of men, and the unsettled state of our colliery labour, the supply as now raised falls very far short of the demand. The consequence is that the market price has lately risen from 50 to 75 per cent. To gas companies this is the most serious matter that has ever happened. They have had to contend against a large increase in the price of labour of the men employed in gas-making, and this enormous rise in the raw material, in addition to the increased cost of labour, will most injuriously affect the dividends of gas companies, and must of necessity compel many of them to increase the price of gas to the consumers. In some cases this can be done, but in other cases companies controlled by statutory power are restricted to a low maximum price, and in numerous cases they are already charging up to their maximum. Consequently these companies are placed in a grave position, and cannot obtain relief without the consent of Parliament. The existing state of things should not be lost sight of in future legislation, for it is inconsistent to have a fixed and unalterable maximum selling price when the cost of manufacture is subject to the great fluctuations under which we are at the present moment so severely suffering.

Another matter of vital importance claims our attention. I refer to the growing tendency of local authorities to absorb the property and business of gas companies by powers conferred upon them by Parliament. In most cases the power of the local authorities is exercised in direct opposition to the wishes of the shareholders of the companies so absorbed. The Legislature, judging from the past, intend to countenance and assist all corporate bodies in effecting this object, and I think that we may fairly predict that in the course of a few years all the principal works in the kingdom will change hands in this way. In the present session of Parliament no less than seven corporate bodies have obtained compulsory powers to purchase the gas-works in their respective towns. There have also been several transfers of works from companies to the local authorities, thereby disturbing a large amount of capital invested in private enterprise. There are, no doubt, good and legitimate grounds of objection to the existing state of these compulsory purchases, but I fear we are helpless in the matter, and must, therefore, in this case submit to the powers

that be. At the same time we must prepare for these changes, and put our respective undertakings in such positions as that they may be able to bear the scrutiny, and of themselves to refute the highly coloured, prejudicial, and overwrought representations that are made in some cases respecting the property corporate bodies desire to become possessed of. We must be well prepared for these attacks, and be true to the interests we represent, and endeavour to obtain for the shareholders of our companies a sum that will adequately compensate for the loss of the property they have matured, and which they have most reluctantly to relinquish.

In concluding my address, I wish to offer to gas managers a few practical suggestions for their consideration. In our official capacities we are subject to much misrepresentation, and the public appear to view us with no small degree of distrust. In some cases it is alleged that we pump air into the gas, in others the complaint is made that, although the price of gas is much cheaper than it was formerly, gas bills are heavier than ever; and it is strongly hinted that either something is wrong in the meter, or that some legerdemain is practised by the representatives of the gas company supplying them. Consumers also complain of insufficiency of pressure, blackened ceilings, and a number of other defects. In practice, you are aware that in nine out of ten cases of complaint the cause is some local defect; it is often either improperly constructed, or worn-out burners, which consume, in many cases, double the quantity of gas that good burners would, and yet give only half the volume of light. Low illuminating power and blackened ceilings may also be traced to the same cause. Defective pressure frequently arises from cheap, ill-constructed gas-fittings, and pipes which are quite insufficient to convey the quantity of gas required to give an adequate supply. In these matters gas companies are, as compared with water-works companies, placed at a disadvantage, inasmuch as the water companies have full power and control over the size and strength of pipes, and the character of fittings used by the water consumers. But in the case of gas companies no such power is possessed, the matter being left in very many cases to unskilful gas-fitters, whose object is to obtain the largest amount of profit on the smallest amount of charge to customers, who demand cheap work. Hence the most paltry and unsuitable fittings are frequently used, which forms a source of constant complaint, and the consumer, from want of knowledge and appreciation, considers the default due to defective pressure.

In these matters I am constrained to say that, as a rule, the consumers have been left to take care of themselves, the gas manager considering that his duty was only to give a proper supply of gas to the meter, and, beyond that, he had no concern, the internal fittings of a house being a matter solely for the consumer to attend to. This conclusion may be correct, but it cannot be a good policy to act upon it in practice. I think it would be most beneficial to gas companies if their officers were to educate gas consumers, and to teach them the proper and most economical use of gas, advising them to have none but proper materials and workmanship. If this were done, we should not have so many allegations as are now made by consumers against companies, and the use of gas for cooking and other purposes would be more general than at present.

With regard to the manufacture of gas, every possible care must be taken to supply it in a pure state and of good illuminating power. We must not lose sight of the fact that chemistry has made considerable advances of late years, and the tests now used to detect impurities are much more searching and delicate than they were. The science of chemistry should be better understood by gas managers than it is at present—in fact, it becomes a necessity, since we have metropolitan gas referees and duly qualified officers in various parts of the kingdom, who give their official reports of the quality of gas supplied to the local authorities, and otherwise detect our shortcomings. We ought not to complain of these severe tests, but hail them with satisfaction, and work hand in hand with inspectors and chemists to make perfect the source of that light which has undoubtedly become one of the great necessities of the age.

We are particularly indebted to the metropolitan referees, and to the engineers who have assisted them, for the valuable practical reports they have made from time to time; and the last, on sulphur, to which I have before alluded, demands the careful attention of the gas manufacturer. Sulphur compounds are highly objectionable, and it has become a *sine quâ non* that a process of purification must be introduced to prevent any sulphur compound reaching the point of

combustion at the burners. In considering this sulphur question attention must also be paid to its formation. A prevailing opinion exists that the high temperature at which clay retorts are now worked eliminates these products in larger quantities; whilst, on the other hand, some chemists of considerable standing are opposed to this theory. For instance, Berthelot has shown that bisulphide of carbon is dissociated into its elements quite powerfully at a bright red heat; and Sidot has published some experiments (in *Comptes Rendus*, vol. lxix., p. 1303) wherein he shows that *more* bisulphide is formed at a dull red heat, and that at a heat approaching whiteness *none* is formed; also that moderate redness is the most favourable condition for its manufacture.

These conflicting views require to be reconciled, for they cannot both be correct. It should, therefore, be the careful study of the gas manager to endeavour to reconcile them, and to find out in practice where the truth lies. Other points requiring attention are condensers and scrubbers, which must be carefully examined and studied, and where they are found to be deficient they must be improved and brought up to the standard of perfection as far as can be attained. Proper and complete apparatus is absolutely necessary in every works. Each minute point of constructure and working details demands the most scrupulous attention, in order that the ultimate results produced may be satisfactory. The progress of science demands that gas managers should make themselves thoroughly acquainted, practically as well as theoretically, with the chemistry of coal gas in all its minutiæ, especially with regard to the more prominent points I have indicated. By these means, and by the light of the reports of the gas referees, I trust that ere long the members of the British Association of Gas Managers will be as successful in producing chemically pure gas as they have been in working the large amount of capital entrusted to their care, and which they have done with such satisfactory commercial results. These results will be in no way impaired; but, on the contrary, cannot fail to be improved by a study of the teachings of science, whose fixed and inexorable laws can never be neglected with impunity.

Mr. R. H. Jones (Dover) read the following paper:—

ON THE VARIOUS METHODS OF COLLECTING GAS ACCOUNTS.

The collecting of an account seems a very simple matter—asking for payment of money due; but that there are various methods of collecting accounts, according to the nature of the trade, will be readily seen—the merchant's acceptances against bills of lading, the co-operative store where ready money is an essential, and the West-end tradesman who gives long credit. With gas companies, also, the method employed is by no means uniform. Two methods are in use with me according to the size and circumstances of the town. In a moderate sized town, where quarterly payments have been in vogue for many years, it would be difficult to divide the year's payments into more than four In small towns we find it desirable to divide the year into five periods—

1. July, August, and September.
2. October and November.
3. December and January.
4. February and March.
5. April, May, and June.

This division equalizes the payments more than the ordinary quarterly collections, and avoids the necessity of the collector calling on the consumers in the month of January, when Christmas bills drop in for payment.

The continental system of collecting gas accounts monthly (although it entails considerable additional labour both in the office and in inspection and collection) works, I believe, very satisfactorily, and, in the long run, I am told, pays for the extra cost, in the reduction to an infinitesimally small per centage of bad debts.

I think the five period system, if it could be more generally introduced into England, would be preferable to the present mode of collecting quarterly. I do not adopt the plan of the inspector leaving a ticket of consumption with the consumer when the index is taken, because I find that inspectors are not infallible, but sometimes make mistakes either in calculating the consumption or in taking the indices, and when a meter happens to cease to register in the middle of a quarter, an inspector cannot well detect this, and having once handed in a record of consumption to the consumer, the correction of the

account, by the addition of the unregistered gas consumed, is a nice point of law, and one very difficult to get over with a consumer who is in the least degree disposed to be litigious. My inspectors, therefore, return their books to the office without giving any information to the consumer. The consumption is calculated and entered in the office, and the accounts prepared at home, and in every case compared by the collector with the previous and corresponding quarters before the account is rendered to the consumer. This sometimes necessitates the retaking of the index, and the discovery that the meter has ceased to register, or that the consumption of gas has been reduced or increased, and the collector thus makes himself pretty well acquainted with any irregularity in the consumption before he asks for payment.

To ensure, as far as possible, accuracy in giving credit for moneys received, I provide that no moneys shall be taken without giving a printed receipt from a separate book provided with a counterfoil, of which one is in constant use at the office for the convenience of customers paying their accounts there, and one in the collector's hands. The counterfoils of these books are examined daily before closing the office, and the moneys received entered therefrom into the collector's cash-book. The collector also checks his cash every evening, and enters particulars. The result of this minutiæ is that from an experience extending over 12 years, and covering a total sum of nearly a quarter of a million of money, I know of only one case in Dover where a consumer called to say he had already paid the account sent in; and that solitary instance had reference to the sum of 1s. which a consumer had been charged for some little fitting job. The money had been paid at the office with the quarterly gas bill, and the particular item referred to omitted from the counterfoil; the collector, however, discovered he had a surplus of 1s. in his cash. That fact was recorded, and remained so till the consumer pointed out that the 1s. in question had been already paid, and the honesty of the collector was at once proved by the fact of the record of the surplus cash on the day the error was committed.

I also provide, as far as possible, for the prevention of defalcations through false returns of arrears. About five weeks before the termination of every quarter I cause a list of arrears to be made out, the total of which (with the cash previously collected during the quarter) must amount to the "sum due" at the commencement of the quarter. This arrear list is carefully examined, and in nearly every case the consumer has a lithographed letter sent him either mildly reminding him of his account unpaid, or, where it is absolutely necessary, plainly telling him that unless he forthwith cashes up, his supply will be cut off. My brother gas managers, no doubt, have learnt by experience that in certain cases one is obliged to be very plain in writing and saying what one means.

I find that by thus calling on and writing to consumers, the "collectable" arrears at the end of every quarter are reduced to about 1 per cent. of the private rental, and that during the last five years, out of nearly 1800 consumers in Dover, we have not had a single disputed account, nor do we scarcely ever resort to legal proceedings to recover our gas bills.

I will now refer to towns where the consumption of gas is small, and where no office staff is employed. In Ireland Mr. Anderson and myself light three such towns. There we have introduced the "five period" system in preference to quarterly accounts. Each consumer is provided with a gas pass-book, containing a couple of sheets of paper stitched in a stiff cover, about 6 inches by 4 when folded. It is ruled for dates, index of meter, consumption, amount due, arrears, total due, amount paid, and a column for signature of the person to whom the cash is paid. The manager or collector has a similarly ruled book, about half as large again, and containing a sufficient quantity of leaves to allow an open page for each meter (a copy is annexed to this paper). This latter book combines a rental-book and ledger, and lasts for four years. It shows at a glance the consumption of gas, period by period, or quarter by quarter, and the amount due for arrears, and whether the consumer always has a clean account at the end of every period or quarter, or if he is a frequent or constant bad paymaster. With the rental-book in his hand, the manager calls on the consumer, inspects the meter, and can make up the account and collect the rental at one and the same time, for his own pocket rental-book, or the consumer's "pass-book," enables him to see, by comparison with previous periods or quarters, if he is correct in the amount he charges. I do not think this latter system is desirable, except in small towns, where the manager is the "multum in parvo" of the concern.

TABLE ILLUSTRATING MR. R. H. JONES'S PAPER "ON THE VARIOUS METHODS OF COLLECTING GAS ACCOUNTS."

No. 16. DANIEL MURPHY, PATRICK STREET.

Date.		State of Meter.	Gas consumed. Cubic Feet.	Amount Due.			Fittings.		Arrears.			Total.			Date of Payment.	Amount Paid.			Signature.
				£	s.	d.	s.	d.	£	s.	d.	£	s.	d.		£	s.	d.	
1871.																			
January	31	563	..	..			..		..			..			..	..			..
March	31	603	4,000	1	0	0	..		..			1	0	0	May 14 . . .	0	15	0	J. M. C.
June	30	628	2,500	0	12	6	..		0	5	0	0	17	6	Aug. 8 . . .	0	17	6	J. M. C.
September	30	656	2,800	0	14	0	..		..			0	14	0	..	..			..
November	30	692	3,600	0	18	0	..		0	14	0	1	12	0	Dec. 2. . . .	1	0	0	J. M. C.
1872.																			
January	31	742	5,000	1	5	0	..		0	12	0	1	17	0	Feb. 5. . . .	1	17	0	J. M. C.

Mr. H. P. Stephenson (London) said according to Mr. Jones's description, Dover was a very happy place, and he only regretted that his own experience did not altogether agree with that of the writer. There was one point in reference to the collection of accounts upon which Mr. Jones had not touched, and that was the desirableness of inducing the collectors to collect as quickly as possible. He had himself found, in a great number of instances, that by increasing the commission in the earlier months, and reducing it in the latter months, and even adding at the end of the quarter a fine for all moneys not collected, there had been a strong inducement created to complete the collection at the earliest practicable period. This was a system which had been adopted by one of the great companies in the south of the metropolis, and from which they derived great advantage. He thought he was right in saying the arrears of that company were rather more than those of happy Dover—viz., about 2 or 2½ per cent., as against 1 per cent. In the district of the Crystal Palace Gas Company at Sydenham, to which he alluded, the collection at one time was only about 56 per cent. of the charge, whereas upon the system now adopted it amounted to more than 97 per cent. The company had five collectors, and at the end of each quarter the whole of the arrears were taken out of their hands and placed in the hands of a special arrear collector to recover. He believed that if a system of this kind were generally carried out gas companies would avoid those cases of defalcation over which sometimes they had to mourn.

Mr. Jones said he quite approved of the suggestion respecting the appointment of an arrear collector in the case of a large company, but the paper he had read did not apply to large companies.

The morning sitting then closed.

The first paper read at the afternoon sitting was by Mr. Mellor, on Dr. Eveleigh's improvements in the manufacture of gas.

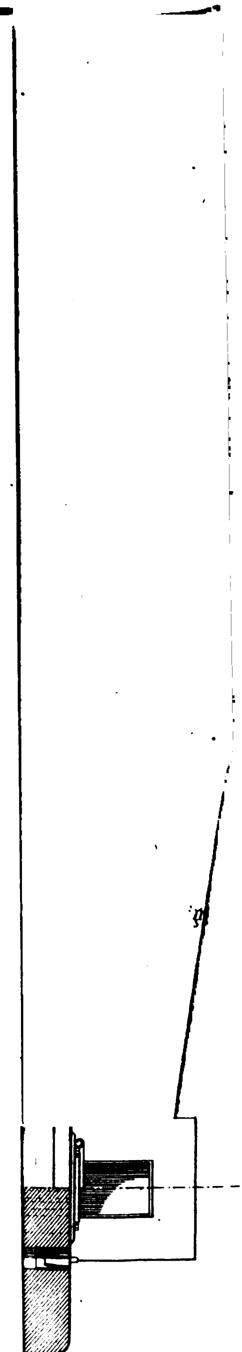
Mr. Mellor introduced his paper by remarking: About a month ago your worthy president asked me whether I could read a paper on this subject before the association. I had no idea at that time of doing so, at least, in the present state of things; but, yielding to his request, I have endeavoured to put a few items of information respecting the patent gas process together, which I have much pleasure in laying before you. They relate more particularly to the mechanical portion of the question. The whole process, as you are, perhaps, well aware from the statements made in the Journal of Gas Lighting, is now under the investigation of two eminent men, and pending their inquiries I have felt it my duty not to enter much into the question of the chemical portion of the invention. Had I done so, it would, as it were, be taking the ground from under their feet; and I am fully aware that they can deal with the matter far more satisfactorily than I could do. With these few words, I will proceed to read what I have to say

ON EVELEIGH'S PROCESS OF GAS MANUFACTURE.

The object I have in reading this paper is to describe the particulars and details of the system of making gas as patented by Dr. Eveleigh, and to give to my fellow gas engineers the results of my own experience arrived at after carefully examining the method on a small scale at the works at Peckham, and also the practical working on a large scale at the works of the East Barnet Gas and Water Company, where, during the last five months, the gas supplied to the town has been made on this principle.

I would wish it to be clearly understood that although I have endeavoured, as an engineer, to assist Dr. Eveleigh to arrange the form and details of the apparatus now used in the manufacture of the gas by his method, so as to render it as nearly as possible self-acting, I have nothing whatever to claim in regard to the principles of the invention, the merits of which, whatever they may be, are due entirely to that gentleman, who has devoted many years of his life to the consideration of this subject.

The system patented by Dr. Eveleigh may briefly be stated to be "the manufacture in the first place of gas from coal under a comparatively low temperature in the retorts of the ordinary shape; and, afterwards, converting into gas the



EVELEIGH'S PATENTS.

Scale

Litho Whiteman & Bass 236, Holborn, London.

greater portion of the rich oils or tar produced by the first part of that process." These two operations are carried on simultaneously, and the two gases are mingled together as soon as they are generated, and pass on to the condensers and purifiers in the ordinary manner in a gas-work.

The first patent taken out by Dr. Eveleigh was dated the 7th of January, 1869, No. 45, and had for its object the conversion of the coal and the whole of the oils and vapours into permanent gas in one continuous process in a manner somewhat different from that patented by Mr. Basford, and, at the same time, to purify the gas by passing it through heated chambers filled with a permeable material consisting of a mixture of charcoal, chalk, lime, iron filings, &c. This method although successful to an extent somewhat greater than what may be called experimental, was found to have some difficulties in manipulation, chiefly in regard to the deposits of carbon in pipes, and the before-mentioned permeable materials, and it became necessary to consider how these difficulties could be overcome, and, at the same time, secure the rich gases which the oil contains.

After numberless experiments, and changes in the form of the apparatus, Dr. Eveleigh found that the best results were obtained by the plan now adopted—namely, that of vaporizing the oil and oily matters *from the surface*, and thus turning all the richer and more volatile portions of the oils into gas, leaving the heavier unvaporizable bodies to fall to the bottom of the vaporizing pan, where they are allowed to accumulate to a certain extent, and whence they are drawn off in the shape of pitch, which, when cooled, becomes hard like the specimen here shown. This system was included in the second patent, taken out on the 21st of February, 1871, No. 443.

The drawings show the whole of the apparatus, beginning with the general arrangement of the retort and hydraulic main adopted for the first distillation of the coal.

The retorts are by preference in section an oval or D shape, with the lower corners well rounded to facilitate the circulation of the heat in the oven. These may be arranged in benches of any convenient number; those at Barnet are set in beds of five to one fire. The coal is placed about 8 inches thick in the retort, which of this size—24 by 16 inches and 9 feet long—will contain a charge of from 4 to 5 cwt. This retort is heated to a dull red heat in daylight, or about from 1200 to 1300° Fahr., which experience has shown me is the most suitable temperature at which the coal should be distilled for all purposes. The gas passes off by the eduction-pipe placed at the upper part of the end of the retort (for reasons which I will hereafter explain), and then down through the dip-pipe to a vessel which I will call with, your permission, an hydraulic main condenser. The gas then passes through the leading-off pipe, to the ordinary cooling apparatus, scrubbers, and purifiers, on its way to the gasholder in the usual manner.

The eduction-pipe is placed at the back of the retort in order that the hot gas, containing, as it does, its oils in suspension, may be carried off as quickly as possible before any condensation can take place in the retort, and where, if the gas remained too long in contact with the heated surface, it would be decomposed and would deposit its carbon, and thereby lose a portion of its illuminating power.

The oils which are condensed in the cistern below the dip-pipe are of rather a light specific gravity, very little heavier than water, and in quantity (including that deposited in the leading-off pipe and condensers) about 30 to 40 gallons per ton of coal, and varying more or less with the quality of the coal. A very small quantity of ammoniacal liquor (from 3 to 6 gallons per ton) is also deposited. These proportions vary as a matter of course with the intensity of the heat at which the coal is distilled. The oils are received together in the ammoniacal liquor in the tar-well, from which the oil is passed into a cistern placed high enough to allow it to run down to the oil distillation apparatus.

This apparatus, which we term the redistillation retorts, consists of three vessels—

1. The vaporizing pan.
2. The intermediate chamber, with a diaphragm across; and
3. The charcoal cylinder.

These are set from the furnace in the reverse order in which they are numbered; for the oil enters the vaporizing pan (1), the vapours then pass up the

ascension-pipe through the intermediate chamber (2), and lastly through the charcoal cylinder (3), where it is converted into permanent gas; whereas the heat is first applied to the charcoal cylinder (3), where it is required to be the greatest (the best temperature, as far as my experience goes, is about 1600° Fahr., or a bright red), then it circulates round the intermediate chamber (2) at about 1100° Fahr., and passing through the nostrils under the arch, over the top of the vaporizing pan (1), where it is sufficient to convert the oils into vaporous gas at a temperature of about 800° or 900° Fahr.

These oils, as you observe, run down from the cistern into which they are pumped from the tar-well to the cock placed above the funnel of the inverted syphon, which acts as a seal to prevent the vapours escaping. The oil is admitted at the rate of about 6 gallons per hour, and it runs down through the pipe into the vaporizing pan, which is filled with oil to above the height of the lower test-cock. The fresh oil flows over the surface of the heated oils in the vaporizing pan, and does not immediately descend to the bottom or mix with the heated oil to any great extent, and thereby that which has been an insuperable difficulty in making gas from oils—any violent agitation and gurgitation—has been prevented. The lighter portion only of the oils is vaporized, and the heavier bodies gradually assuming a greater density as the vapour passes off, fall to the lower part of the pan. These are discharged about every twelve hours, and when cooled become pitch of various degrees of hardness, according to the length of time they are exposed to the heat of the chamber.

The vapour rises up the ascension-pipe, and passes through the intermediate chamber, where it is gradually heated to about 1100°, or a very dull red. The object of the diaphragm is to prevent the passage of unvaporized oil into the charcoal cylinder by the sudden passage of the gas and vapours through the intermediate chamber, and also in the case of any possible gurgitation of the oil in the vaporizing pan, to intercept the frothy, oily matter which runs back again through the dip-pipe into the pan. The gas and vapours then pass downwards, permeating through the incandescent charcoal in the charcoal cylinder, the vapoury matters being decomposed, and the oils thus converted into permanent gas. The gas then passes at the back of the apparatus from the exit-pipe at the bottom of the cylinder to the condenser, where any oily vapour which has not been thoroughly decomposed in its passage through the charcoal cylinder is recondensed, and returns to the tar-well, where it mixes with the fresh oil from the first distillation of the coal. The gas at this point is mingled with that of the first distillation, and the two gases pass on together to the condensers.

The most important feature in the manufacture of gas by this process is the heat at which the coal is distilled in the retort, for on this, in a great measure, depends the quantity and quality of the gas obtained, and what is most important, the quality of the oily matters; for if too great a heat be applied, the gas will have less illuminating power, a greater amount of sulphur in the shape of —to use the "referees" phrase—"sulphur compounds other than sulphuretted hydrogen" will be formed, and the oil will be rendered almost useless for further treatment for conversion into gas, and if too low a temperature be used, there will be but a small quantity of permanent gas generated, and a greater quantity of oil, whilst the residue, in the shape of coke, would be of very little use.

In the distillation of coal at a high temperature the sulphur combines freely with the carbon, giving rise to the formation of bisulphite of carbon, but a portion also of the sulphur unites with the earthy compounds and carbon in the coke, while another portion passes off as sulphuretted hydrogen; whilst in the distillation of coal at a low temperature almost the whole of the sulphur passes over as sulphuretted hydrogen, a portion of which unites with the ammonia, forming hydrosulphuret of ammonia, which is readily absorbed by water and gradually becomes sulphate of ammonia, free hydrogen passing on with the gas; hence, in the latter process, the coke is freer from sulphur, and little or no bisulphide is formed.

So far as my experience goes, I have found that a dull red heat, or temperature of what I should consider about 1200° to 1400° Fahr., is the best for all purposes. The charge of coal for a retort 9 feet long, 24 by 16 inches in section will be about 4 to 4½ cwt., and this, at the temperature employed, requires twelve hours to obtain all the gas from the coal. From several trials of Norfolk Silkstone coal made by me at the works at Peckham, I have selected, as a fair

average, the following, as showing the rate of production of gas at each hour during the charge, which weighed 4 cwt.:—

1st hour . . .	190 feet.	7th hour . . .	150
2nd „ . . .	240	8th „ . . .	140
3rd „ . . .	170	9th „ . . .	130
4th „ . . .	150	10th „ . . .	120
5th „ . . .	150	11th „ . . .	110
6th „ . . .	150	12th „ . . .	60
		Total . . .	1760

The total produce was thus 1760 feet, or at the rate of 8800 per ton of coal, the illuminating power being 25 candles. The quantity of oil, as near as I could ascertain, was about 6 to 6½ gallons, or at the rate of about 30 gallons per ton of coal, with very little ammoniacal liquor. The amount of sulphur in the gas, according to Dr. Letheby's test, was 3·24 grains in 100 feet. This was, of course, a laboratory experiment, but it was made with a full-sized retort, and with a full charge of coal in the same manner as would be used in large works, and therefore the inference is that with a reasonable allowance for working on a large scale there ought to be a similar quantity of gas produced from every ton of coal. We have hitherto, at East Barnet, used only the Norfolk Silkstone coal, but in our experiments at Peckham we have tried many other kinds of coal, and obtained similar results, varying in quantity and quality with the relative richness of the coal.

The redistillation apparatus is arranged of such a size as to distil the whole of the oil produced from a bench of 10 retorts, and it is advisable that the oils should be used at once in the same proportion as they are obtained from the coal (for these oils are very volatile, and lose a considerable portion of their gas-producing properties if they are kept for any considerable time), and that the two gases be mixed in proper proportions, so that the quality may be regularly maintained.

The quantity of gas obtained from the distillation of the oil is about from 100 to 150 cubic feet from a gallon of oil. I have, as yet, had no reliable means of testing the illuminating power of this gas separately, and as it is not intended by the inventor that it should be used separately, but that the two gases should be mixed as soon as they are generated and used together, we must take the results of the two combined processes in endeavouring to ascertain its value.

The quantity of gas which, in my opinion, may be relied upon as obtainable from the Norfolk Silkstone coal by the combined process, will be from 10,000 to 11,000 cubic feet to the ton, and as the oil gas is not so rich as that from the coal, the illuminating power is considerably reduced by the mixing, the average being a little over 20 sperm candles from that coal.

The duration of the charge in first distillation of the coal being 12 hours, the quality of the coke is much improved, it becomes much harder, and consequently there is less breeze. The quantity produced is also greater, averaging in the Silkstone coal used at Barnet about 14 to 14½ cwt. per ton of coal. The consumption of fuel, in consequence of the low heats at which the retorts are worked, is less than it would be with the present system of high temperatures, bu t as there is also the second distillation to provide for, the fuel account may be taken to be about the same on the whole as by the present system in ordinary works of the same magnitude.

Up to the present time we have used iron retorts only, for at the requisite temperature there is little or no deposit of carbon in the retorts, and I do not think it will be possible to keep clay retorts gas tight at so low a heat. This, however, has yet to be tried, and if it can be done successfully, it will materially affect the cost of wear and tear. I have had considerable experience in the use of iron retorts under the old method, and from that experience, considering the low heats adopted by the Evelcigh process, I should unhesitatingly say that the wear and tear account might safely be taken at the same rate per 1000 feet as with clay retorts under the high heat method. There has not yet been sufficient time in which to do any more than form an estimate of this matter.

Any number of retorts may be set in one bench or oven, and I think it will be found advisable to have the redistillation apparatus arranged in proportion of 1 to every 10 or 12 retorts. This would open an inquiry as to the space required, and I admit that it is a very important question, especially to those who have

their works in the middle of large towns; but it must be borne in mind that as much larger charges are used, and as the heats required are low, a greater number of retorts may be set in one bench. In my opinion, it will be quite safe to calculate that not more than one-fourth more space will be required for this process to make the same quantity of gas than for the ordinary method of gas manufacture. The labour cannot be more than that required in ordinary gas-works, for one man can easily attend to six sets of the oil apparatus, all that is necessary being to attend to the furnace and see that the oil is kept flowing regularly, and once in every 12 hours, or thereabouts, to discharge the pitch from the vaporizing pan.

Having now described the apparatus and the manner of working the process, and having in the course of the paper given you my opinions on the production of gas and of the residual products and other matters, I now come to the questions which most of you will agree with me are the most interesting to every one concerned—Will it pay? What is its value commercially? Is there any practical difficulty in adopting it in daily use on a large scale? On these three questions the merit or failure of the system depends. Now, I take it to be the duty of every one connected with gas interests to inquire into these matters, and when any new invention or process is brought to their notice, having for its object an improvement either of the quality or purity of the gas, and also professedly giving an increased quantity from the same amount of coal, to see whether there is any truth in the statement set forth by those introducing them; and to this object I have very naturally turned my attention as regards this process.

Dr. Eveleigh states that by his process the following advantages are obtained:—

1. That the quality and illuminating power of the gas are much greater from the same quality of coal.
2. That the sulphur impurities are very much smaller than by the high heat system.
3. That the cost of the gas per 1000 feet is less.

These, if they can be justified, are very important results, and it now becomes my duty to give you in a few words the result of my own experience during the twelve months I have had my attention constantly on the subject. It would be useless and perfectly unprofitable to put down the figures as to the exact cost of the gas per 1000 cubic feet at the station meter, for in every town and in every gas-works, large or small, the individual items bearing upon the cost of gas are different in every case, both as regards the value of coal and coke and the other residuals, the cost of labour and materials, and other local circumstances. I can only give you the data I have arrived at, and it will be for each of you who desire it to form your own estimates according to the local circumstances of each case.

The coal I have used at East Barnet is that from the Norfolk Silkstone pits, belonging to Messrs. Newton, Chambers, and Co., and on that quality my data are placed. Many other coals have been tried experimentally, but on full sized retorts at Peckham, and the results have almost invariably been in the same relative proportion as regards quantity and quality as the same coals yield under the ordinary process. From this coal we obtain, including the oil distillation, from 10,500 to 11,000 cubic feet per ton.

The average illuminating power for the last two months is over 20 candles. The quantity of sulphur is under seven grains in 100 cubic feet.

These are results obtained practically at the East Barnet works during the last five months, and the testings for quality have been made strictly under the "referees" rules at a distance of 1100 yards away from the gas-works, and on the ordinary main-pipes of the town. In addition to the above three points, the following are the conclusions arrived at in my own mind as to the merits of the system, whatever kind of coal may be used:—

1. That the quantity of gas made is greater, and the quality much better, than by the ordinary method.
2. That the labour is not more.
3. That the fuel will cost the same, or thereabouts.
4. That the wear and tear account will not be higher than by the ordinary method.

5. There is no difficulty whatever in the manipulation, nor choking of the eduction-pipes or apparatus.
6. That the gas, when made, is quite permanent, and produces no deposit in the mains beyond that of gas made in the ordinary manner.
7. The coke is greater in quantity and better in quality.
8. The space required to make the same quantity of gas in the same time will not exceed that required by the ordinary method by more than one-fourth.

And lastly, that the additional cost of the apparatus, including the oil stills, will amount to about £25 per retort in the first instance.

These are what I feel fully convinced are reliable data, on which the three questions asked may be answered; and, acting as the consulting engineer of the company who owns the patents, I cannot do more than give my opinion in the way I have. For myself, I have no doubt whatever that all the questions may be answered satisfactorily, and I strongly recommend the system to your careful attention.

The works at East Barnet are open to any member of the association who desires to see them, and every information will be given by the superintendent to visitors.

I fear that I have made my paper, though very imperfect, yet much too long, and that some of the details given are dry and uninteresting, and, perhaps, many of you will doubt the accuracy of the opinions I have given. I may be wrong, for I am not infallible. I can only say they are the honest convictions of my mind, and as such I give them to you *quantum valeat*.

To those engineers and managers who are bound by their respective Acts of Parliament to a high standard of illuminating power, it seems to me to be invaluable; for by this process the use of cannel coal, up to 20-candle illuminating power, may in many cases be dispensed with.

I have said very little of the chemistry of this matter; that is now under the examination of two very eminent men, well known in the gas world, and their report will soon be made on the whole subject.

The President invited observations upon the paper just read, and said he was sure Mr. Mellor would have pleasure in replying to any inquiries made, and in furnishing any further information on the subject in his power. He hoped the members of the association, as practical men, would not allow the opportunity to pass without a thorough ventilation of the question, which all would agree was a most important one. The tendency in the present day was to require from gas companies an increase in the illuminating power of the gas supplied by them. To meet this demand, the companies were put to very great expense in the purchase of cannel coal; and if, by any invention, the cost of production could be reduced, there was no doubt it would prove an immense boon. It was the duty of gas managers carefully to consider the question without prejudice, and when an opportunity like the present offered for obtaining information respecting a system whereby it was alleged that gas of a high illuminating power could be manufactured from common coal without the use of cannel, to avail themselves of it to the utmost.

Mr. Clift (Redditch) said, in opening the conversation, he felt bound to express his own feeling, which, he thought, was also the feeling of every gentleman present—viz., that the association was under great obligation to Mr. Mellor for the very able paper he had just read, and also for the fair and candid manner in which he had laid the whole matter of Dr. Eveleigh's process before the members. He confessed that he came to the meeting a disbeliever in the system—a disbeliever from having himself, some years ago, tried the process of making gas at a low temperature with very unsatisfactory results. It was a necessity at the time, because he was then working iron retorts, in which high temperatures could not be employed without very heavy wear and tear. He had also used a process similar, in some respects, to Dr. Eveleigh's for manufacturing tar into gas, and the results there, also, were by no means so satisfactory as those detailed by Mr. Mellor. In speaking of the invention now submitted for consideration, they must regard it, not exactly as Mr. Mellor had described it—viz., as one process—it consisted, in reality, of two distinct processes. There was first the manufacture of coal into gas in iron retorts at a low temperature, and, secondly, a subsequent manufacture of the resulting tar into gas. Now, all gas makers, especially

old gas makers, knew what it was to use iron retorts worked at a low temperature, and that they could not get 9000 or 10,000 cubic feet of gas per ton of coals in them as they could with clay retorts. The first process of Dr. Eveleigh's was a going back to the most antique method of making gas—the method by which Clegg made it in the first instance, and which certainly could not, as a rule, be adopted for economy's sake. By the process under consideration a larger quantity of tar was produced than by working at a high temperature, because this product was not decomposed and converted into gas It was then proposed to take that tar and subject it to another and entirely distinct manufacturing operation, just as much so as if they bought tar in the first instance, and employed it in the production of gas. There was a distinct apparatus for the purpose, and so many cubic feet of gas were obtained from a given weight of tar. His own experience was that from 10 lbs. of tar he could make 100 feet of gas. But 10 lbs. of what tar? The very richest product from tar—the naphtha, the aniline. What was that worth per gallon? It was worth 1s. 3d., and from a gallon of that product it was proposed to manufacture gas to the value of 3d. The rich oil of naphtha, from which aniline was obtained, was worth 1s. 3d. per gallon in the market, and, with the whole of the apparatus which had been described, it was proposed to make this into threepennyworth of gas. He would ask any one whether this was likely to prove a paying process. Mr. Mellor said he would not go into the details of the profit and loss very minutely, but if he had done so, and had told the meeting what was the value of that rich portion of the tar which he converted into gas, there would have been no difficulty in arriving at the conclusion to which he (Mr. Clift) had arrived. Then Mr. Mellor stated that the cost of fuel in the Eveleigh process was much about the same as in the present mode of manufacture. Now, was it reasonable to suppose that with these two distinct processes for the production of 11,000 feet of gas, and with two fires constantly going, the cost of fuel would be no greater than in the production of 9500 feet or 10,000 feet of gas with one fire? He thought the thing was palpably erroneous, and that it must be evident the cost of fuel would be greater. As to the cost of labour he could not say much; probably not much additional labour would be required, assuming the correctness of Mr. Mellor's statement that no stoppages occurred in the pipes, and that the whole process went on without much attention. Of course, the redistillation process was to a certain extent self-acting. There was a cistern of tar above, the contents of which ran down at a certain speed into the evaporator. The rich hydrocarbons were evaporated in that chamber, and passed into the retorts, and he supposed the coke was seldom changed, and therefore the labour would not be great. Still, there was additional labour. With iron retorts making 7500 or 8000 feet of gas per ton of coal instead of 9500 or 10,000 feet, the labour must be greater in proportion to the quantity of gas made, because the charging and discharging were the same, the attention to the fires was the same, although from 20 to 25 per cent. less gas was obtained. To produce the additional quantity of gas, additional labour was required in the second process. What that was he could not say, and Mr. Mellor had very wisely left it to be ascertained by experience. He (Mr. Clift) did not propose to say anything further than that he admired Dr. Eveleigh, or any other man who, when he thought or believed, as no doubt he most thoroughly did believe, that he had discovered something of public advantage, was determined to follow it out and thoroughly investigate all its parts. If there was, after all, nothing in his invention, it would, like a thousand other things they had known, drop out of sight in the course of time; if, on the other hand, it possessed any practical value, these investigations would establish the fact, and the public would soon appreciate it.

Mr. Allan (Willington) said he remembered about 13 years ago a patent was taken out by Mr. Basford for making oil or tar and water into gas, and he was so unfortunate as to allow the process to be tried at his works. It seemed to him to be a process in many respects similar to the one now under discussion. His experience, however, was that unless the thing was continually watched, there was a danger of accident with it, and in his case one night the whole place was blown up, the man in charge had his leg and the small bone of his arm broken, and the company had to pay his wages all the time he was necessarily lying idle.

Mr. H. P. Stephenson said he sympathized very much with the poor man whose arm was broken by Basford's patent, but he was happy to state that no

such accident had happened at the Barnet works with Dr. Eveleigh's patent. He rose to point out to the meeting that there was a very material difference between this and Basford's patent. Mr. Basford conducted his process in an ordinary retort, and passed the gas so manufactured through a charcoal chamber. But here there was an entire redistillation of the oil produced in the first process. He felt a great deal of interest in this question, and his friend, Mr. Mellor, had kindly allowed him to see the works at Barnet. He quite admitted that the thing was in its infancy at the present moment, but he believed it would ultimately prove a most valuable discovery, and it struck him as a matter most worthy of consideration, particularly at this time, when the price of coal and cannel was increasing to so fearful an extent. By it—upon the word of Mr. Mellor, which they had no reason at all to doubt—they would be enabled to get from 10,000 to 11,000 cubic feet of 20-candle gas per ton of common coal. Mr. Clift, who spoke against the patent, said he never got that; Mr. Mellor said he had; therefore they had the testimony of the man who had eaten the pudding against that of the man who had not had any. And not only was the fact of production vouched for, but there was the additional fact that the gas of this high illuminating power had been carried to and tested at the burners at a proper distance from the works. There was one consideration which had occurred to his mind in the first instance as a most serious objection to the use of this process. Take the case of his own company at Sydenham. They had a rental of £50,000 a year. What would be the effect on that rental of supplying to the consumers gas of 20-candle illuminating power instead of 15 as at present? Of course, the result would be to depreciate *per se* the rental to the extent of a third or a fourth. Now this was an objection which would rise in the mind of a great number of persons who were not tied to a high standard of illuminating power as at Liverpool, Manchester, and in Scotland. Supposing the rental of his company reduced in the way he had mentioned, it would have a most serious effect upon their profits. But the way in which he looked at it was this—that even assuming the public were not induced by the higher illuminating power and greater purity of the gas supplied, at the same price as before, to use a larger quantity, he thought it would be found of advantage to the company to adopt this process in combination with the ordinary methods of manufacture, so as to obviate the necessity for employing cannel coal. By so doing, they would be able to supply to the public gas of, say, 16 or 18 candle power, so that, as in the case of his company, instead of lowering the price of gas which happily in past years they had been enabled to do, but which they might not be able to do in the future, they would be in a position to meet the demands of the consumers by raising the illuminating power. In this way, at all events, he thought the patent might prove useful to those gas companies which were not bound to a very high standard. In other cases, such as with the Brazilian companies, where a high illuminating power was demanded, the patent process would be valuable, because it would save the necessity for shipping cannel coal, and thus enable them to make their gas much cheaper.

Mr. Fraser (Inverkeithing) said Mr. Mellor had vouched his word as an engineer to two very important facts—first, that with the same quantity of coal he could by the new process obtain a greater quantity of gas; and, second, that the gas so obtained was of a much higher illuminating power. He (Mr. Fraser) had seen the gas made at Barnet, and had no doubt at all that the illuminating power was much increased—probably it was double that of the gas in ordinary use. Under such circumstances the question was well worthy of consideration and careful investigation by all gas managers, seeing how largely the price of coal was increasing. But there was one point which appeared to him ought to be explained, and therefore he would ask Mr. Mellor a question upon it. Would gas made in the way patented by Dr. Eveleigh be permanent, or would it be condensed into oil?

Mr. Anderson (London) thought the only point omitted by Mr. Mellor in his paper was how much pitch per ton he had obtained.

Mr. Smith (Hyde) wished to know the difference in the specific gravity of the two gases—the gas made from coal, and that made from the oil or tar.

Mr. Anderson said he had the strongest desire imaginable to believe every statement made by Mr. Mellor, and that for two reasons. Mr. Mellor had placed the subject before the meeting in a most candid and gentlemanly manner, and it would be very much to his (Mr. Anderson's) interest if everything stated in

the paper was reliable, because he was a manufacturer of gas, and had to purchase large quantities of coal. He was therefore in that mental stage of being open to conviction; but he confessed that he was not yet convinced, and he would state in a few words what occurred to him at the moment as being against the system now under consideration. This was the first time, he would venture to say, in the experience of any one present, in which they had heard of a larger quantity of gas being made at a low than a high heat, and he hoped it was a fact, as stated, that the gas so obtained was permanent. It was also the first time they had heard of low heats being able to produce gas as cheaply for labour as high heats, and he was afraid, while giving Mr. Mellor credit for the utmost sincerity in what he stated, that this was a point which he had not thoroughly analyzed and made himself properly conversant with. In the first place, Mr. Mellor stated that, with a retort 9 feet long and 24 by 16 inches in section, he carbonized 4 cwt. of coal in 12 hours. Now, in the ordinary mode of manufacture a retort of that size would take say 3 cwt. per charge, and there would be four or five charges per day, according as five or six hour charges were worked. There must, therefore, be a considerable increase of labour to obtain the same quantity of gas by the first process. Then as to the fuel account, he could not help thinking the cost must be much greater. His own experience was, that in consuming fuel at a high temperature greater calorific value was obtained from it than at a low temperature. In the next place, there was a second process to go through. Certainly this second process was very beautiful, and appeared to him very perfect. Probably it did require very little labour, but he did not think it would require so little fuel as was supposed, because it really made half as much gas as the first process, although there was only one redistillation apparatus to distil the oil from a bench of 10 or 12 retorts. This was a matter which, perhaps, was open to argument. The quantity of oil or tar obtained was about 30 gallons, and the production of gas from that was at the rate of 150 cubic feet per gallon, therefore there was between 4000 and 5000 feet of gas per ton manufactured from the tar alone. In the first process he believed that the cost of fuel must be more than by the ordinary mode of manufacture, and that in the second it would be from one-third to one-half of that. He was quite prepared to admit that the gas would be of a high illuminating power, because, as was well known, where low heats were employed, though less gas was obtained, it was always of a higher illuminating power than where high heats were used. He was obliged to Mr. Mellor for stating that the works at Barnet were open to the inspection of any members of the association who desired to see them. Whether that visit should be paid before the eminent doctors who were investigating this matter made their report was a question; perhaps if they went there with the report in their hands they would be better prepared to find fault, as it would be their duty to do if they saw it necessary, and thus give those in charge of the process the opportunity of putting pegs in all the holes they made. He wished it to be clearly understood that in anything he had said he had no desire to depreciate the merits of the invention; indeed, he should be happy should it prove to be a success. He only desired to indicate what he conceived were objections in a commercial point of view, and it would be a great satisfaction to hear those objections successfully refuted.

Mr. Price (Llandudno) asked Mr. Mellor to state upon what data he had come to the conclusion that only one-fourth more space would be required for working this process, to make the same quantity of gas, than for the ordinary method of gas manufacture. This was a very important question to those who might have to enlarge their works to adapt them to the new process.

Mr. Hutchinson (Barnsley) said he should be glad if Mr. Mellor would give some particulars as to how he ascertained the heat, the quantity of gas produced, and whether there was more coke and more tar than by the usual method of manufacture.

Mr. G. Livesey said he thought perhaps it was due to the association that as this system was now to be tried at the South Metropolitan works, he should state, as concisely as possible, the reasons why he had recommended his directors to give it a trial. Before he paid a visit to the Barnet works he was very sceptical on the subject, for he took very much the view Mr. Anderson had taken, that this was the first time anything of the kind had been attempted, and he was doubtful whether it could succeed in this instance. He was not able to make any experiments at Barnet himself, but his friend Mr. Mellor, whom he had

known for many years, gave him certain facts and figures in the same way that he had given them on this occasion, and it was from those facts and figures he had come to the conclusion that the thing was worth a trial. There seemed to be no doubt of this, that the gas produced from common coal was of extraordinary illuminating power, and also that it was of extraordinary purity. The point to be determined was, could it be so produced as successfully with regard to cost, as by the ordinary system, taking all the circumstances into consideration. That was well worth ascertaining, and therefore he recommended his directors to give it a trial. One thing which particularly struck him in connexion with the invention was the method of distilling the oil. Hitherto in effecting that object the heat had been applied round the oil chamber—at any rate not upon the surface of the oil. The result was to boil the tar and cause it to give off heavy thick carbon vapours which choked up the pipes. By this system the heat played over the surface and evaporated the more volatile constituents, leaving the pitch undisturbed to settle at the bottom. Although Dr. Eveleigh's plan seemed in some respects to be going back from the practice of later years, it was quite possible some of them might be mistaken respecting it. It was said at one time that steam-ships could never cross the Atlantic, and it struck him while Mr. Clift was speaking, that there was some analogy in the matter. Certain it was, that Mr. Mellor had succeeded in doing that which Mr. Clift found it impossible to do. If only on the ground that by means of this process they could make gas of a very high illuminating power without the use of cannel, the system was well worth a trial. Those companies which were under restrictions as to the quantity of sulphur allowed to be present and which were bound to a 15 or 16 candle standard, would find an advantage in making a portion of their gas by this system, and thus improve the average quality.

Mr. H. Brothers (London) said he was deeply interested in this matter, having been a cannel gas manufacturer all his life. He thought he might speak confidently when he said that he was able to make as much per ton or per mouthpiece as most people, but he certainly did not make anything like the quantity of gas he desired to make from Scotch cannel. In practice, he found that he was from 10 to 25 per cent. behind in the results obtained by chemists and experimentalists; and it struck him that the invention of Dr. Eveleigh's might come in to his aid in this matter. If cannel coal was distilled at a low temperature, and the tar was redistilled in the manner proposed, he thought it quite possible to obtain the results which chemists stated as attending their experiments. He was inclined to believe that the invention would not answer commercially, as applied to common coal, and that in respect of coke, although Mr. Mellor stated that he got a greater quantity per ton, it was inferior in quality to that produced in the ordinary way, because it must contain a great deal of tar. With regard to labour, he agreed with Mr. Clift that the cost must be greater. Here there were two distillations, and not only so, but they were dependent upon human agency, which was very fallible. Every one present was aware that gas managers in London had the misfortune to be under the referees; and to be under the referees meant that they were bound to a minimum as to illuminating power and purity. They also knew from experience that if they used a certain portion of a given material they would produce a certain quantity of gas of a certain illuminating power. But, supposing they adopted this process, and some carelessness in the working of the second portion arose, they might obtain an admixture of the two gases which would bring the illuminating power below the minimum, and thus expose them to the liability of a penalty. Then, it occurred to him that man could never make his compounds do as well as those which were provided in nature. In nature cannels were found of a certain quality which it was known by experience would give a certain illuminating power, but if they came to mix these, and to rely upon human agency, they would often be wrong. He thought it would require the greatest attention and care to manufacture—say 16-candle gas (which meant 17 in London)—by this process. He was quite convinced, from what he had seen at Barnet, that the wear and tear must be greater than usual, and that the cost of fuel would be higher. Although the heat required was not so high, the time during which the retorts were kept at work per charge was much longer, so that the consumption of fuel must be considerably more; and in addition to that, there was another fire to keep up. Under all the circumstances, he was of opinion that at present prices the process would not pay as applied to common

coal; but where very rich materials were employed in the product of gas, as in Brazil, which had been referred to, it might answer.

Mr. Warner (South Shields) remarked that if the invention justified the encomiums of its advocates, and produced 20-candle gas from common coal, the consumers had a good friend in Dr. Eveleigh, because of the saving it would enable them to effect in dispensing with the use of expensive cannels. Mr. Livesey stated that at the South Metropolitan works they were about to erect apparatus in order to give the system a trial. He (Mr. Warner) would be glad to be informed what the cost of such apparatus would be, and whether the Patent Gas Company would charge a royalty for its use in the event of the experiment proving unsuccessful. Probably the company were so well convinced of the correctness of the principles upon which the process was based that they were prepared to erect apparatus and allow the process to be tried for the actual cost without expecting a profit out of the trial.

Mr. Darwin (Longton) said he thought that at present prices selling tar must be as good as distilling it, so that as far as his company were concerned he did not see there would be any advantage in adopting the process.

Mr. Parlby (Aylesbury) asked Mr. Mellor to state whether in carrying out his process there was any difference in the mode or cost of purification.

Mr. Woodall (London) said there was one point which he felt very anxious to have made a little plainer, and that was as to the relative amount of work that would be done in the space of time mentioned as compared with the ordinary process of manufacture. Mr. Mellor stated that he had no doubt whatever as to the relative quantities of gas produced from the first distillation and the second. He thought he gathered from the paper what was the quantity of gas made from the coal, and as they knew the gross quantity it did not seem that there need be much difficulty in ascertaining the amount made from the second process. But as he understood the figures in the paper, it appeared that altogether with both processes the quantity of gas per mouthpiece with these very large retorts was under 4000 cubic feet. Now, if according to this invention the size of the retorts was increased, and the space required was increased, and additional apparatus was necessary for the second process, while at the same time the quantity of gas produced was less than that obtained under present arrangements, it certainly appeared to him that this must be rather a costly improvement. If the production of gas, too, was prolonged, the cost of fuel and labour must also be increased. On these points Mr. Mellor, who appeared quite disposed to give every information in his power, would probably be good enough to throw a little light.

Mr. Irons (Gosport) said he should have been pleased to have some details as to the photometer testings. Gas made from two processes combined sometimes chemically and sometimes mechanically, and the illuminating powers varied.

Mr. Hunter (Rochdale) wished for some further information as to the amount of labour required in working the apparatus. From what he could see a greater amount of skill was required in making gas according to this method than by the ordinary processes. In the practical operation of gas-making very much depended upon the stokers, and he felt somewhat doubtful of the results if they were to be intrusted with an apparatus which was more complicated and demanded more skilful manipulation than that in general use. He felt bound to take this opportunity of expressing his thanks to Mr. Mellor for the courteous and extremely candid manner in which he had brought this subject before the meeting, and also for his readiness to afford him all the information he sought when he visited the works at Barnet.

Mr. Peebles (Edinburgh) said he was probably the only person present who heard a paper read some time since by Dr. Macadam, on short time charges and the mixing of different qualities of coals, in which the writer showed, in a tabulated form, that the result of the combination of high quality coal and coal of an inferior description was to produce gas in large quantity and of a very high standard of illumination. By the process now under consideration the coal was distilled at a very low heat during a long period of time, and he (Mr. Peebles) imagined that at the tenth or eleventh hour the gas evolved must be of a very low illuminating power. The question was whether this gas would combine with the gas evolved during the first part of the operation and the gas distilled from the tar, and unitedly form gas of a high quality, and at the same time of

good volume. Probably there was a chemical solution of the discrepancies between Mr. Mellor and the other gentlemen who had spoken.

Mr. Mellor said he felt very much indebted to the members of the association for the very kind way in which they had received his communication, and the courtesy with which they had stated their objections and raised inquiries. He need hardly say that all which he had stated he thoroughly believed. He would proceed as briefly as he could to reply to the questions put to him. The first remark made and the first inquiry proposed was by Mr. Clift. That gentleman said he had been using iron retorts for a long time; that he got from 8000 to 9000 cubic feet of gas from them; that he worked them at certain heats, and that he found tar would not make gas so as to be profitable. Now if iron retorts were worked at a very low temperature indeed, not more than half the quantity of permanent gas would be generated, and there would be a large quantity of oil; whereas, if worked at a high heat, they absolutely destroyed the gas-bearing properties of the oil, and it was of no use attempting to make anything of it. In working at a high heat in iron retorts a carbonaceous deposit was formed on the inside of the retorts, and they generated that which the referees made so much bother about, the troublesome compound bisulphide of carbon. This impurity has been, so to speak, very much thrust down the throats of gas managers lately, and that, too, in a very disagreeable form; but, after all, there was very much in the complaints made about it, and he was convinced that its presence was owing to the very high heats employed. Mr. Clift stated that he obtained 1s. 3d. per gallon for his tar, but he (Mr. Mellor) never before heard of tar selling at that price.

Mr. Clift: No; I said I obtained 1s. 3d. per gallon for the light oil distilled from the tar—*i.e.*, that which you take from the tar to manufacture your gas with.

Mr. Mellor: The benzole, you mean.

Mr. Clift: The naphtha.

Mr. Mellor: I thought you said you made 30 gallons of tar per ton of coal, and got 1s. 3d. per gallon for it.

Mr. Clift: I wish I could. What I said was that the oil you take off to convert into gas is worth 1s. to 1s. 3d. per gallon in the market at the present ime.

Mr. Mellor: Allow me to ask how many gallons per ton, and then I can get at the result.

Mr. Spice (London) said 2500 gallons of tar would produce 70 gallons of the oil which Mr. Clift stated to be worth 1s. 3d. per gallon.

Mr. Mellor, proceeding with his reply, said Mr. Clift called the Eveleigh process two operations, but it was in reality only one, for the whole was carried on in the same place, at the same time, and by the same men. The first process was to make from 7500 to 8000 cubic feet of gas per ton from the coal, and as he took it, it did not matter whether they turned the oil obtained into a still and redistilled it at the same time, or whether they left it alone; the quantity of gas obtained in the aggregate was what they must base their calculations upon. Mr. Clift stated that he had been able to get 8000 or 9000 feet of 14 or 15 candle gas per ton from his retorts, worked in the ordinary way, whereas he (Mr. Mellor) had obtained 7500 or 8000 feet of 25-candle gas per ton, by adopting a proper heat, from the first distillation process. He then had from 30 to 40 gallons of oil, which he converted into gas—permanent gas—making, say, an aggregate of 11,000 feet per ton, to be within the mark. He had never been able to get more than 1½d. or 2d. per gallon for tar, even with benzole at 2s. 6d. per gallon in the market, and it was not worth that now. With regard to fuel, that seemed to be a very important question in the minds of some of the friends present. They all knew that if they burned their fuel as they ought to burn it so as to obtain the largest amount of calorific value, it did not matter whether they burned it at a high or at a low heat; there was a certain amount of heat to be obtained from the fuel, if proper attention was given to its economical consumption. Now in the heats employed in the Eveleigh process, from 1200° to 1300° Fahr., they must exhaust from the fuel in the same time very much less of its calorific property, so that as a matter of fact the fuel would last longer. They did not require so much heat to maintain a cherry red as to maintain a white heat; and when it was remembered that they put from four to five cwt. of coal in each retort to obtain 10,500 feet of gas per ton, by these two processes, it would be seen that they did not in reality require more

fuel. His experience at Barnet was that during five months the fuel had not averaged more than 25 per cent., although working at great disadvantage, sometimes having 5 retorts going, sometimes 10, and sometimes 20, and the conclusion he had arrived at was that with so low a temperature in the first process they saved as much fuel as was required in the second process. Mr. Allen asked whether there was any choking of the pipes. To this he (Mr. Mellor) replied that in this process there was absolutely no choking at all of the pipes. During the time that Dr. Odling and Mr. Keates were examining the works, the eduction-pipes were untouched for 14 days, and when they were afterwards opened in his presence they were as clean as his hand. Mr. Stephenson, speaking of the invention of Dr. Eveleigh, very properly said that it would be a valuable auxiliary to gas companies, enabling them to make 15 into 20 candle gas; and what he (Mr. Mellor) would ask the members of the association to consider with regard to illuminating power was this, that in the present day the tendency of legislation was to raise the standard in this respect, and gas managers must be prepared to meet it. Now, as they could not very well make from any description of coal which came to London, except it might be the Silkstone, gas of 16-candle illuminating power without the admixture of cannel, this process came to their help in making gas of that description, avoiding the necessity to use cannel at all; and he recommended it to their attention on that account. With regard to the permanency of the gas, that was a point upon which he never had the slightest doubt from first to last, though he had thought it possible that like all other gases it might, if kept a long time, lose a little of its illuminating power. There was one thing upon which he had been sceptical—viz., whether the two gases would mix; and it appeared to him that this would be one of the greatest difficulties. To settle the question, he put the two gases into a gasholder, and introduced one pipe at the top and another at the water level of the holder. On burning from each, there was not a quarter of a candle difference in the illuminating power of the two gases, neither could he find any difference in the specific gravities. This satisfied his mind that there had been a thorough commingling of the gases. With regard to permanency, a test was applied at East Barnet, for which he was little prepared. At the time Dr. Odling and Mr. Keates commenced their experiments the whole of the gasholders were full, and it was determined to shut off the inlet and outlet pipes, and leave them in that condition till the experiments were finished. The gas was kept in the holders for 15 days, and on being tested was found to have lost only 1½ candle of illuminating power. Further than that, the gas was tested at a distance of 1100 yards from the works; he selected a house at that distance so as to conform to the rules of the referees; and for four months there was no deposit appreciable at the syphon on the main. If the gas had not been permanent there must have been a deposit, but, in fact, there was none; *ergo* it was permanent. Upon that point he held a very strong conviction, and, therefore, he boldly stated in his paper "that the gas when made is quite permanent, and produces no deposit in the mains beyond that of gas made in the ordinary manner." Mr. Anderson asked the quantity of pitch obtained, but he did not ask what was the quality of the pitch. The quantity varied from 70 lb. to 80 lb. per ton of coal, and the sample on the table would be seen, upon examination, to be of a very soft, rich-looking character, and he thought it would be found to contain, except the benzole and the aniline, most of the other valuable products of that article. He could not say much more upon that subject, but perhaps Mr. Goddard, who knew more about it than any one in the room, could supply further information. He believed if carefully analyzed it would, as he had said, be found that, with the exception of the lighter hydrocarbons, this pitch contained most of the valuable properties of tar—the anthracene and other matters referred to by the president in his address. If that were so, it proved that the 3000 feet of gas—or 100 feet to the gallon taken out of it—was obtained to their hands for nothing. With regard to the remark made by Mr. Anderson as to going down to see the works, what he said was this—that ever since he had been in a position to show the works, he had never refused, to any engineer who had asked for it, the privilege of seeing them, and that he would be happy to see not only Mr. Anderson there, but every one else in the room. But he had been asked before he was ready to allow people to see the process. Had he consented, he would have had nothing to show them, and it would only have been to occupy the time of the applicants and his own to no purpose. In

a new thing like this, many alterations had to be made in order to bring the operations into practical working, but for the last two months the works had been open to the inspection of any one, and if Mr. Anderson would pay them a visit he would be happy to devote a day to the examination of the process with him. In retorts of the size employed—viz., 24 by 16 and 9 feet long—he could put about 9 feet of coal, which was nearly 4½ cwt. If he attempted to get all the gas out of that in six hours, he should fail in doing it; but by burning it for twelve hours, he got, with the oil distillation, nearly as much gas on the same space as was obtained in the ordinary method of manufacture, and therefore he thought he was quite within the mark when he said that one-fourth more space would be required in the new process to make the same quantity of gas in the same time. In reply to the question as to the specific gravity of the gas, he stated that he had not tried it by itself in such a manner as to be able to give any reliable information, but it would be ascertained much more satisfactorily than he could do it by the gentlemen now engaged on the investigation. Mr. Price mentioned something about the heavy charges, and said he could take off the gas in four hours. If a higher quality of coal or cannel was used, the time would be reduced to five or six hours. The higher the quality of the coal, the less time would be required to take the gas off; that was, he believed, the result of general experience. Mr. Jackson asked how he ascertained the heats. They were ascertained by Bailey's calometer. The quantity of gas was ascertained by the station-meter, and the quality by the referees test. Mr. Brothers would forgive him for saying that he quite disagreed with one observation made by him. He expressed his opinion that the coke made at a low heat was not so good as when a high heat was employed. He (Mr. Mellor) maintained that it was better. Coke, when made for foundry purposes, in coke ovens, was subjected to a low heat, which was gradually increased to a high heat, and exposed from 24 to 30 hours at a time. If drawn off at 5 or 6 hours, it was not so good as when left for 12 hours; and the longer it was burned, within reasonable limits, the better. With regard to the question of the cost of labour. The only labour required in the redistillation was to pump the oil up into the cistern, from which it ran into the stills, and to keep the fire going. The charcoal employed in the charcoal cylinder did not seem to depreciate in quantity, but it did in quality, and in time required to be changed—say, once in about two or three weeks. Every three or four days it was necessary take off the cover and loosen the charcoal. With these exceptions, there was little or nothing to do in the way of labour; and he thought he was right in stating in his paper that one man could easily attend to six of these stills without the least trouble whatever. In reference to the temperature at which he had been working, he had been chiefly guided by the amount of sulphur in the coal employed, so as to bring the quantity in the gas down to 6 grains per 100 feet, according to the contract with the Barnet Company. The lower the temperature, within reasonable bounds, the less sulphur there was in the gas; and as the temperature was increased 100° by 100°, so he got a grain or a grain and a half additional sulphur per 100 feet. With that exception, he saw no difficulty whatever with regard to dependence upon human or mechanical agency. He believed that any man with ordinary intelligence could attend to the process; and he was justified in saying so by the fact that, with the exception of the foreman, who was changed last year, the same men were employed now at the Barnet as were at work there before the new process was introduced. He had made all these statement in good faith, and must leave them with the members of the association to think over. If they required further information, he would be happy to furnish it on the spot at Barnet. One member asked whether the gas obtained was really of 20-candle illuminating power. He could only say in reply that the daily testings had conclusively shown it to be so, with one or two exceptions last month, when it went down to 19·59 candles. As to purification, he might state that no claim was made to interfere with this part of the manufacture, which could be carried on as in the ordinary way at gas-works. As to the quantity of gas per mouthpiece, he found that five retorts with twelve-hour charges gave 16,000 feet. The oil process brought this up to 22,500. Dividing that by 5 gave 4500 cubic feet per mouthpiece. He could not give the make per man at the moment, he could only say that no more labour was required per ton of coal used than usual, except for the distillation process, and the quantity of gas obtained from that covered the extra labour employed. Mr. Irons asked a ques-

tion in reference to variation in illuminating power, in reply to which he would state that during the last two months the gas at Barnet had not varied more than 1½ candle between the highest and lowest point, and that the two gases did regularly mix he had already remarked. He believed he had answered what Mr. Peebles said about short charges. He did not think it was good policy to mix the coals in the distillation for gas. If they had a coal—say a cannel—which passed away its gas in three or four hours at a moderate temperature, and that was mixed in the same retort with a lower class coal, which took five or six hours, there was no economy in this; it was better to distil separately and mix afterwards. The only other question he had to answer was that put by Mr. Warner, and he was sure that no one would blame him for saying it was hardly likely that Dr. Eveleigh or those who worked his patent would allow it to be used for nothing. If the system was what he claimed for it, it must be a very good thing, and by good he meant commercially good—there must be a saving in it, and Dr. Eveleigh, and those associated with him, would expect to reap the advantage of the invention. The agreement made with the two or three companies who had determined to try it was this—in one case they were to pay so much per 1000 feet; in another, as suggested by Mr. Stephenson, so much per retort. He did not think the Patent Gas Company would wish for anything like a heavy royalty in the matter. He had always advised them to take a low rather than a high royalty, and he had no doubt whatever satisfactory arrangements would, in all cases, be effected. With regard to the cost of the apparatus, the company were now putting up for the South Metropolitan and Crystal Palace District Gas Companies two sets at cost price. In the one case the cost was not to exceed, including many things that would do very well for more retorts, £600 for ten retorts, and in the other, £1000 for twenty retorts. As he stated in his paper, he believed the additional cost of apparatus, including the oil stills, would amount to £25 per retort in the first instance. In conclusion, he begged to thank the members for the kind manner in which they had listened to his observations.

The President said, as the representative of the members of the association on that occasion, he thought he might fairly thank Mr. Mellor for the candid manner in which he had entered into the description of the new process of gas manufacture. Mr. Mellor, coming forward as he did to meet a body of gas managers, no doubt expected that the principles and details of the invention would be critically viewed, and he was sure that he would not feel aggrieved by the spirit in which these had been commented on. It behoved those who occupied the position held by members of the association not to be biassed against any professed new discovery, but to look at it carefully and judge of its merits on scientific and commercial grounds. The gist of Dr. Eveleigh's patent process appeared to be that he volatilized more carbon than in the ordinary mode of gas-making, and he claimed that by mixing the two gases so made he gained a considerable increase of illuminating power. But after having heard all that Mr. Mellor had to say on the subject, he (the president) must express his opinion that they had not yet got what they required to determine the point—viz., what was the true commercial value of the process. Mr. Mellor, he was sure, had given them every information as far as he was able, but no doubt he was restricted in some respects, and had acted wisely in not going into this part of the subject. His (the president's) only fear was that the two gentlemen referred to, who were chemists, would at the close of their investigations only report upon the matter chemically, and that the desired knowledge of commercial results would not be acquired from their researches. With reference to the permanence of the gas made by Dr. Eveleigh's process, Mr. Mellor had tested it as far as he could, but, as a practical gas manager, he (the president) would much have preferred a statement that Mr. Mellor had ascertained by the station-meter for a given time that the make of gas had been so much, and that during that period the consumers meters had registered so much, and the public lamps had consumed so much. By deducting the one from the other he would have been much better able to judge of the permanency of the gas than by the experiments which had been made. In company with several gentlemen, he (the president) had been to Barnet to see the process in operation, and was received by Mr. Mellor with great kindness, and supplied with all the information in his power. The process seemed very plain, and the result satisfactory; but after all, as commercial men, they must look

at the balance-sheet, and unless good returns in that direction could be exhibited, it was of little importance, comparatively, how beautiful or ingenious the arrangement might be. At present they had not obtained all the data necessary for demonstrating that matter. It was evident, however, that 20-candle gas could be produced from common coal, and this was an important step in the right direction; for even if the thing went no farther, he agreed with Mr. Stephenson in thinking the invention might be satisfactorily utilized in raising the standard of ordinary common gas as required by Act of Parliament.

Mr. WARNER (South Shields) read the following paper

ON GOVERNORS AND THE GOVERNOR ROOM.

I have to differ on this subject, as I have done in my paper on meters, with the author of the "History of the Gas-Meter." He writes, "The reflection is irresistibly forced upon us of the advantage which has arisen from the original defects of the meter, for to that is probably due the invention by Clegg of that simple and useful instrument—the Governor. I believe the two instruments were separate and distinct inventions, and the germ of the two was found in the gasholder." "One of the uses of the gasholder," Peckstone writes in 1823, "is to regulate the emission of the gas toward the burners, which could not be effected without such contrivance." And Accum, in 1819, says, "Various methods have been adopted to attain this object, to preserve the gas of an invariable density, some of which were exceedingly ingenious and creditable even to such as Malam." "But the expensive and cumbersome specific gravity appparatus," Accum proceeds, after describing some of these arrangements, "has been wholly superseded by an ingenious contrivance called the regulator or governor. The action of this machine, for which we are indebted to Mr. Clegg, is that it regulates the gas prior to its entering the mains to any required degree, whatever its density may be in the gasholder."

Mr. Clegg's invention was patented December, 1815, and is described in the specification thus: "The pipe through which the gas passes to the burners must have in some part of it an aperture which is capable of being increased or diminished in its opening by a very slight force, and motion for increasing or diminishing the aperture is given by a small gasometer or inverted vessel, the mouth of which is immersed under water, and its interior capacity communicates with the pipe of supply beyond the part where the aperture for regulation is placed. The operation of the governor is to regulate the pressure with which the gas shall be urged to issue from the burner. This pressure is determined by means of a certain load applied upon the gasometer, so as to occasion a sufficient difference between the level of the water inside the gasometer and the level of the water on the outside thereof; the action of the governor will be to keep this pressed constantly the same."

We have here, in the clearest possible manner, the theoretical construction and operation of this exceedingly simple machine; and in neither could we, with our additional fifty years experience, improve. But in the actual construction there was a defect which had to be, and was at once remedied—the valvular arrangement—the substitution of a cone for the hydraulic valve. This doubtless, was done by Mr. Clegg, as Peckstone says it was Mr. Clegg's practice to make his governor with a cone. There was another, but a slight defect, and not of much practical importance, early discovered in use, though it must have been known at the time of the invention. Mr. Crosley appears to have met the loss of weight and pressure of the gasholder by its immersion; for he, as will be seen by Accum and Matthew, on the History of Gas Lighting, made the holder conical, smaller at top than at bottom. Dr. Muspratt quotes Hughes as his authority for proportions of governor; he says the tank is usually somewhat less in depth than the diameter, and with the capacity of about two cubic feet for every 10,000 feet of gas required to be passed through in twenty-four hours, and he gives a holder of 4 ft. 6 in. deep and 5 ft. diameter to an 8 in. valve.

The object of this paper is to give this association the results of a practical examination of the ordinary governor on each of these three points:—First, as to the form of valve; secondly, loss of pressure by immersion; thirdly, the relative proportions of valve and holder. As to the form of valve, Clegg says it must be an aperture capable of being increased or diminished in its

opening by a very slight force, but there is also another condition that it be possible to entirely close it. Among the number of patents that have been granted for governors and regulators, every possible form of valve has been pressed into the service, but none appear to answer the conditions laid down so well as the cone moved by a very slight force and perfectly valvular. The relative proportions of cone employed may not be uninteresting.

Clegg, jun., "Manufacture of Coal Gas"	6	diameter of base.	
Clegg, per Accum and Peckstone	4	,,	,,
Dr. Muspratt, "Chemistry, Arts, and Manufactures"	4	,,	,,
Wright, per Edge's patent (parabolic)	2	,,	,,
"Hughes on Gas-Works," as revised by Richards......	2	,,	,,
Crosley, specification patent regulator	2	,,	,,
Malam, per Accum and Peckstone	1	,,	,,

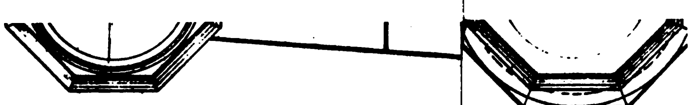
It was in an arrangement of the governor as an inferential meter that the parabola, I believe, was first employed. Hughes says the opening can be adjusted with much greater certainty when the parabolic form is used instead of the true cone, as will be evident if we consider that sections of a parabola parallel to the base decrease in direct proportion to the height at which they are taken, whereas the sections of a true cone decrease as the square of the height. It follows then that a parabolic piston will open or close a space in exact proportion to the height through which it is lowered or raised, whereas a truly conical piston will open or close a much larger space when the part near the base of it rises one inch than when the upper part of the cone rises through the same height.

This leads us to the second point, the gasometer, the holder, the bell, the float, as it has been called; the volume chamber, perhaps, would be the best name to distinguish it by, for it is by the increase or diminution of volume only that a perfect regulation of pressure is effected, and it is this which distinguishes the true governor from all others, however ingenious it may be. Several arrangements have been patented of the adaptation to the governor of the ordinary pressure-gauge, with valve and float on the gas column; but it is evident there can be no change of volume in such an instrument without a change of pressure, as the action of the instrument is entirely dependent upon the change of pressure. The diaphragm, however, gives a true volume chamber, the weight is constant, the resistance uniform, hence a variable volume with a constant pressure. Doubtless, the best form of volume chamber is that of the original—a small gasholder in a tank of water—but there is a variable pressure in its action from the displacement of the water.

Crosley seems to have been the first to meet this defect with his conical chamber, and Wright, in the machine before alluded to, has a weighted arm to fall from the vertical when the chamber is just out of the water, to the horizontal when immersed, thus compensating for the loss of weight as the holder descends by an increased leverage of the weighted arm. Sugg's photometrical governor has a somewhat similar arrangement. It will be seen by the diagram that this compensation is not uniform—the leverage not corresponding with the space passed through—thus, as shown with only five-tenths of the space passed through, there are nearly seven-tenths of the compensation spent. By the cycloid, however, a perfectly true, steady, and frictionless compensation is effected. In this, as shown in the other diagram, the leverage and space passed through are equal—five-tenths of the space and five-tenths of the compensating lever. By the use of the cycloid, then, we have a perfect volume chamber that will give motion to a valve for regulating the flow at an uniform pressure. Hughes gives a capacity of two cubic feet to tank of governor for every 10,000 feet of gas to be passed.

In the discussion upon Mr. Hunt's governor at our last meeting, it was stated that the "area of the gasholder should be as many times the area of the cone as it is desired to reduce the pressure;" and, again, that "they bear a direct proportion to each other." Mr. Hunt also says in his paper "that those governors are most to be depended on in which the greatest difference exists between the area of the gasholder and the bottom of the cone;" and against this it was asserted that "small gasholders, with large cones, had been found to work admirably enough in certain conditions."

The results of an examination of what has been published are as follow, arranged from the lowest diameter of base of cone :—



W. J. Warner;

Eng

Mr. G. Anderson, per Clegg	2½ times	2½ deep.
Mr. S. Clegg, specification	4 ,,	11 ,,
"Hughes on Gas-Works," as revised by Richards	5 ,,	5 ,,
Mr. Clegg's fourth edition "Gas Lighting"	5 ,,	4½ ,,
Mr. L. W. Pritchard, ditto	6 ,,	5 ,,
Mr. Wright, Edge's patent..	7 ,,	3 ,,
Mr. S. Clegg, jun., second edition "Gas Lighting"	7½ ,,	6 ,,
Mr. J. Malam, per Peckstone..	8 ,,	3½ ,,
Mr. S. Crosley, specification diaphragm	10 ,,	— ,,

It is a source of considerable regret that I cannot give you the results of experiments upon the three points I have dwelt upon—the form of valve, the action of volume chamber, and the relative proportions of these.

I place before you an apparatus for the purpose, but which was not finished in time to try the experiment for this paper. With the permission of your committee, I will hand in the results of experiments to the secretary for publication with the transactions of the association.

I will now briefly draw your attention to some modifications in the governor which I have made, and had in use some time at the South Shields Gas-Works. The first is an entire enclosure of the whole working parts of the governor, not only the gasholder or volume chamber, but also the shifting counterbalance, so that it is not possible for any accident to happen in the working of the governor.

The holder being entirely enclosed, communication with it for adjustment is by a bridle and lever keyed on to a horizontal shaft passing through a stuffing-box, the lever and counterbalance being also enclosed in a case. Attached to the lever is a small cord passing over pulleys, and actuating a spindle carrying a fixed and a loose pointer; the fixed one is for indicating the area of valve opening, and the loose one is for registering the maximum opening during the twenty-four hours. I have also attached an equilibrium arrangement of valve. In a separate tank there is a floated holder of the same area as the base of cone, to which it is connected by means of a cord passing under two pulleys; the interior of holder communicates with the inlet, and the outlet pressure acts upon the exterior of the holder, so that the valve is thus balanced. I have this attached to a governor with a cone 16 in. diameter at the base, and the pressure is perfectly steady from nil to 5 inches. Dotted in in fig. 3 is another arrangement, which I have had in use for the last seven years. The top of the inlet pipe is turned true, and the underside of valve plate is also surfaced, the plate lies loose in its place, and is of sufficient weight to resist any ordinary action upon it by the cone, but in case of a stoppage of engine, &c., the cone carries it up from the top of the inlet pipe, and so effects a simple bye-pass. The lever form of counterbalance is here very useful for returning the valve to its normal condition of exhausted governor.

Richards is the only one who has given the governor-house a separate article in a work on gas lighting; no other author has mentioned it. I have distinguished this building as the governor-room, because, in the case of most works, it would be more convenient and economical in working for it to be but part of a building not to be used only for valves, meters, and governors, but for the whole of the mechanical work of the establishment, engines, exhausters, pumps, and a workshop with lathe, screwing machine, &c. In my own works space is very limited, and I was unable to carry this into practice, so that I have but the valves, meters, and governors, with pressure gauges and registers, as shown in the drawing. I do not know that there is any great novelty in the arrangements.

Besides the outlet-valve of holders being in the house, I have a bye-pass direct from the meters into the cylinder for feeding the governor. Each outlet of governor has a connexion to a meter for the purpose of testing each district during the time of non-consumption. The meter (A, fig. 6) was not fixed for this work, but for a purpose which will show the value of thoroughly districting a town and working it at the pressure most suitable for it, not only as to its level, but also as to the nature of the consumption. At Shields, not far from the gas-works, is a very fine market square, filled with stalls, exhibitions, &c. On a Saturday night and other occasions, all these are well lighted from stand-pipes rising from the ground, the fittings of which never being in order the loss of gas was very considerable. The market, too,

being supplied from the principal main at the initial pressure, the consumption was very great, and being contract lights the loss to the company was considerable. This I remedied by running a separate main to the market and fixing a meter and governor; and, instead of the gas blowing away at two inches pressure, it was reduced to one-third for lighting, and then entirely shut off during the remainder of the twenty-four hours.

So with the other portions of our district. Near to the town is a little village at a considerable elevation above the town; this was cut off from the town-main and worked at a proper pressure, instead of that of the town. The riverside portions, too, having factories—some of which were working all night, and others starting early in the morning—required different pressures from the quieter portions of the town. Jarrow, with its large iron shipbuilding-yard and chemical and other works, being from three to four miles from the gasworks, again, required and has a very different pressure from any other portion of our district. The result of these changes, and a more careful attention to other details of distribution, is a very considerable reduction in the quantity of gas unaccounted for.

Mr. Hartley said Mr. Warner expressed surprise that there was so much divergence in the character of the cones of governors. He (Mr. Hartley) thought that this divergence had arisen from a misapprehension as to the proper form. The true cone was objectionable because it required an enormously long stroke to produce the best effects, and the effects which it did produce were unequal for equal lengths in part of its stroke, and this also rendered the scale of the instrument unequal in its significance. As the result of experience, he found the parabolic form the best, and that it was not necessary that the length should exceed twice the diameter. If even shorter the cone would, under certain conditions, do its work quite well. As to the proportion between the gasholder and the cone, that varied with a variety of circumstances. Mr. Warner said that Mr. Wright had given a certain ratio between the cone and gasholder, but he (Mr. Hartley) never knew that Mr. Wright had ever done so. He (Mr. Hartley) however knew as a fact that Mr. Wright had made governors with gasholders and cones in very different proportions to each other. A great deal depended, at times, not on the will or conviction of the makers of governors, but upon the will or conviction of the engineer for whom they were made. For his (Mr. Hartley's) own part, he knew that when the holder bore the proportion of about six times the diameter of the cone, a thoroughly efficient working governor was the result. The gasholder could with advantage be made smaller than this proportion, but if very much smaller the governor required a regulating diaphragm or some controlling arrangement, as otherwise there was a tendency to jumping and oscillation. In some governors the gasholders were made larger than was absolutely necessary in other respects in order to afford space for a float, while with others the question of appearance had to be considered. With reference to the enclosure of the governor, he confessed that he did not believe in it. He thought the governor was an instrument which should have its gasholder visible, and he had not found in his experience that men tumbled against it, and so did harm, which was suggested by the writer of the paper as a reason for covering it up. In respect to the chances of disarrangement or disturbance a tolerably large gasholder was good, because the action of the instrument would be less affected by rough manipulation. In theory, therefore, a large gasholder was advantageous, but in practice a smaller holder was as good, if the governor were provided with a steadying arrangement, such as he (Mr. Hartley) had mentioned and applied.

Mr. Hunt (Vauxhall) said he thought it should be borne in mind in respect to the relative proportion of the cone and the gasholder actuating it, that much depended upon the pressure at which the gas issued—*i.e.*, the action of the gas upon the bottom of the cone. Where there was a tendency to great variations of inlet pressure the relative proportion of the cone and the gasholder should be greater. It had been assumed by the writer that it was absolutely indispensable for a governor to have a cone, but he (Mr. Hunt) had the honour at the last meeting of the association to submit a form of governor in which a throttle-valve was substituted for a cone. The advantages of such a substitution were obvious—they got rid of the enormous dimensions

necessary now to have in the cone form of valve. All that was required to be overcome was the friction necessary for the bearings of the throttle-valve, which, by his arrangement, was reduced to a minimum, while the most satisfactory results were obtained.

Mr. HARTLEY said that in his remarks he had addressed himself to the consideration of cone governors only, as Mr. Warner's paper treated of no other kind.

Mr. PATERSON (Warrington) said he quite agreed with Mr. Hartley. He thought there was no proper, or perhaps he should say no better form of cone than the parabolic. All other forms had certain objections. The proportion of the diameter to the length Mr. Hartley had rightly represented as about one to two, but he was not quite prepared to agree with him on the subject of large gasholders, because he did not consider they were needful. He had been accustomed to use governors as governors, but he did not depend upon them to furnish the needful quantity of gas during the height of the supply. In addition to his governors he had by-pass valves for the purpose of regulation, and made use of his governors as governors. Consequently he had a pretty long range in them with a flange, and he found no tendency in them to create a blinking. He did not think large gasholders were necessary even for large mains, and he was at the present time putting down a 16-inch main with only a 12-inch area for the governor, which he apprehended would be found quite sufficient for all purposes.

Mr. WARNER said the principle of shutting off the pressure was recognized and provided for in the first governor constructed. With regard to the shape and size of the cone, the principle for regulating these points was clearly laid down by Mr. Clegg in the quotation given in the paper just read. He (Mr. Warner) did not think that either the shape, size, or form, had anything whatever to do with the regulation of pressure, provided the volume chamber passed through the whole range of its travelling unaffected. He had not seen governors with balance or throttle valves, but he thought it must be a very difficult matter to make a truly valvular aperture by means of a throttle-valve so that it should be perfectly gas tight.

Mr. J. STORER (Stafford) read the following paper on

AN EXHAUSTER SPEED REGULATOR.

There is but very little difference in the opinion of engineers and managers of gas-works that an exhauster is an indispensable part of the manufacturing plant, although there is to some extent with reference to the labour required for working it, and the financial results obtained thereby. It is, therefore, the object of my paper to lay before the members of this association a simple and inexpensive arrangement, whereby much time and labour of the man in charge of the engine and exhauster may be saved. As a matter of course, this will be a greater desideratum in the majority of provincial works, where the foreman stoker is in charge of the engine, than it will be in large establishments, where it is requisite to keep a man for that particular purpose. In all works, however, it is essentially necessary that the speed of the exhauster should be so regulated as to maintain an uniformity of pressure in the hydraulic main; and the usual method of accomplishing this is by a governor A, connected with the inlet-pipe to the exhauster, which rises or falls accordingly as there may be a pressure or vacuum at that point. It is also attached by a vertical rod B, and horizontal lever C, to a throttle-valve, fixed in the steam-pipe leading to the slide-valve of the engine; the valve being opened or closed by the action of the governor, thereby regulating the speed of the engine, by controlling the supply of steam. But with this arrangement, the engine does not work with that regularity which is always desirable it should do, in consequence of the distance of the throttle-valve from the steam-chest; the action of the governor is not quick enough to prevent a considerable variation in the pressure in the hydraulic main. Now, the link motion, by being connected to the intermediate shaft D, entirely obviates this fault by its direct action on the slide-valve E, either shortening, or lengthening the stroke instantaneously; thereby shutting off or admitting more steam as may be required. In other words, the engine is made to work expansively, whereby a saving of steam, and consequently of fuel, is effected.

The saving of labour is accomplished by the link motion maintaining constantly, without any alteration, the requisite pressure or vacuum in the hydraulic main, either during the maximum or minimum make of gas through the day. Providing the steam is kept within a range of 20 lbs., that is, supposing 30 lbs. is the requisite pressure, it will allow of a variation say from 25 to 45 lbs. This I consider to be a great desideratum in a moderately sized works, where a stoker has charge of the engine, because it saves him the trouble of leaving his work during the time he is charging the retorts, in order to attend to it.

Another object gained by the regularity of the working of the exhauster is a prevention, to a great extent, of the formation of carbon in the retorts; and, consequently, an improvement in the illuminating power of the gas.

In introducing the subject of my paper to this meeting, I have endeavoured to be as brief as possible, still I hope that whilst I have endeavoured so to do, I have not failed to make myself sufficiently clear, so as to be perfectly understood by all to whom I have had the honour of reading it.

The proceedings then closed.

At the Evening Sitting the following Lecture was delivered:—

ON SULPHIDE OF CARBON.

By Dr. Odling, F.R.S., F.C.S., &c.

Sulphide of carbon, although a very minute constituent of coal gas, can scarcely be regarded as an unimportant constituent; at any rate, if we bear in mind the large degree of importance so commonly attached to it. I propose to consider with you this evening, the properties of this sulphide of carbon, and more particularly the circumstances under which it is formed, and the circumstances under which it is decomposed, with a view to your making use of the information I hope to put before you, by giving it some practical application. It is known to us all that when coal is heated in a retort, as in the manufacture of gas, a large proportion of the weight or substance of the coal is resolved into volatile products of different kinds. Of these products, the least volatile become condensed into tar, the intermediate into ammoniacal liquor, while only the most volatile or least condensable remain in the form of permanent gas. And this permanent gas is found to be composed mainly of the three elementary bodies—namely hydrogen, carbon, and oxygen—which together constitute the great mass of the organic, or organically derived, substance, coal.

It is an interesting point, in the consideration of the action of heat upon coal, to observe that in the produced gas, each of the three principal constituents of the coal appears in almost as many gaseous forms as it is possible for it to appear in. We find that the hydrogen of the coal appears largely in the state of free hydrogen gas, so as to constitute indeed not unfrequently one-half of the bulk or volume of the permanent gas. Then we have a portion of hydrogen combined with oxygen in the form of aqueous vapour, and another portion combined with nitrogen in the form of ammonia; while by far the largest proportion by weight of the hydrogen occurs in combination with carbon, in the form of different gaseous or vaporous hydrocarbons. Similarly in the case of oxygen, a portion appears united with hydrogen in the form of water; another portion appears united with carbon, so as to form the carbonic acid gas, removed in great measure from the illuminating gas before its delivery; while a third portion appears also united with carbon, but in the form of carbonous oxide gas, which remains as one of the inflammable constituents of the gas delivered to consumers. So again with regard to the carbon of the coal, it occurs among the volatile products of the distillation partly in the oxidized forms of carbonic acid and carbonous oxide, and very largely in the form of different more or less luminiferous hydrocarbons. At present we can only take cognizance of the fact that the gaseous products of the distillation of coal have this multiform character. A far more intimate knowledge than we at present possess would be required to enable us to explain the conditions under which the different products, in their different relative quantities, are produced.

A point of much interest with regard to the carbon products of coal distillation is their great degree of volatility. Carbon in the uncombined form is especially characterized by its infusibility and fixity in the fire. We cannot even melt it, still less can we volatilize it. In this respect it differs from the greater number of elementary bodies with which chemists are acquainted, and from a large proportion of compound bodies. As a rule, if we take any definite chemical substance and apply an increasing heat to it, one of two things happens—either it ceases to be the substance it originally was, that is to say, it undergoes a chemical change into new products, or, remaining the same substance, it melts, and at a still higher degree of temperature, it boils; and very few indeed of the large number of substances known to chemists are capable of resisting such processes of heating as are now available, without on the one hand, undergoing decomposition, or, on the other hand, undergoing fusion or volatilization. And this property of volatility is possessed by elementary bodies and by bodies of simple constitution, to a greater extent than is generally supposed. A piece of silver, for instance, may not only be melted as a piece of ice is melted, but at a far higher temperature, indeed, it may be boiled as water is boiled; and just as in laboratories, when we require pure water, we have recourse to distilled water, so also when we require absolutely pure silver we have recourse to distilled silver. But in respect of its fixity, or non-volatility, carbon or charcoal is a most remarkable substance. So long as it continues chemically unchanged, heat it as strongly as we can, we are incapable of fusing or volatilizing it. But cause it to enter into chemical union with some other element—with oxygen, or hydrogen, or nitrogen, or chlorine, or sulphur—and we obtain compounds of which the most characteristic property is their volatility. And to such a degree, indeed, is this the case, that out of the only three compound gases known to chemists which have never been reduced to the unvolatilized or liquid state, two of them—namely, carbonous oxide CO, and marsh-gas CH_4—are compounds of carbon.

I want now to direct your attention to the circumstances under which some of these volatile compounds of carbon are produced—not indeed during the distillation of coal in gas-retorts, by virtue of complex reactions which have been but very imperfectly studied—but to the circumstances under which they are produced by the direct combination of their constituent elements. And, in particular, I want to consider with you the conditions under which carbon enters into union with oxygen on the one hand, and with hydrogen on the other hand, in order that we may afterwards study with advantage the conditions under which it unites with sulphur to form disulphide of carbon. In respect, then, of its union with oxygen, charcoal or carbon, especially in its looser forms of aggregation, is remarkable for the low temperature at which it takes fire and burns. Here is some crushed wood charcoal gently heated in a porcelain dish, standing at some distance above a small Argand gas-flame; and you observe that the charcoal in the dish is glowing hot—not made glowing hot by the small gas-flame, but made hot enough to take fire of itself, and so to become and continue glowing hot. If I blow a current of air on it, it burns with greater vivacity; and if I now blow on it a current of oxygen, it burns, you observe, with very great brilliancy indeed, and with development of a very high degree of temperature. Now whether this charcoal burns at a high or at a comparatively low temperature, provided it has a sufficient quantity of air or oxygen with which to combine, it always burns into the same product, namely, carbonic acid gas; and the act of burning is an evidence to us of the chemical combination taking place between the carbon and the oxygen of the air, to furnish the carbonic acid.

You well understand that for the heated charcoal to continue burning, one essential condition is involved, namely, that the amount of heat given out of the burning tending to keep the charcoal hot, shall exceed the amount of heat dissipated by radiation and contact with the surrounding air tending to make the charcoal cold. A piece of red hot iron held in the air quickly becomes cold, and a piece of red hot charcoal is subjected to the same cooling influences; which are, however, counteracted to some extent by the amount of heat given out, in this latter case, by the burning of the charcoal. In a charcoal fire, then, where each piece of charcoal receives heat from its neighbour in exchange for what it yields thereto, we have continuous burning; but a solitary piece of burning charcoal soon goes out, the amount of cooling

it experiences by radiation and contact with the cold air being in excess of the heating it experiences as a result of its combination with the air.

So much, then, for the continuous combination of carbon with oxygen to form carbonic acid. But there is another compound of carbon with oxygen, namely, carbonous oxide, to which we must devote a few moments consideration. It would appear that this last compound is never produced directly from air or oxygen, but only through the intervention of carbonic acid. With carbon burning either quickly or slowly, at a high or at a low temperature, carbonic acid is the first product furnished; and when this so produced carbonic acid further passes through a mass of strongly-ignited fuel, as commonly happens in a briskly-burning coke fire, it takes up more carbon and is thereby reduced to the state of carbonous oxide CO, which burns with its characteristic blue flame on the surface of the fuel:

$$CO_2 + C = 2CO.$$

Now whereas hydrogen in the free state, occurs among the constituents of coal gas, the nearest approach to free carbon that we meet with is this carbonous oxide, or, so to speak, half-burnt carbon; and it is noteworthy that, in the act of burning, these two inflammable gases alike unite with half their bulk of oxygen, and by their oxidation evolve substantially the same amount of heat:

$$H_2 + O = H_2O; \quad CO + O = CO_2.$$

Having thus remarked upon the combination of carbon with oxygen, we have next to consider its combination with hydrogen. If we take a piece of carbon of any kind, and, having heated it very intensely, introduce it into a vessel of hydrogen, the ignited carbon enters into combination with the hydrogen, though far less actively than it would with oxygen; and inasmuch as, by its combination with the one gas as well as with the other, a certain amount of heat is given out, we may say, if we like, that the carbon burns in the hydrogen as in the oxygen. But there is this important difference, that whereas the amount of heat given out by the union of the ignited carbon with oxygen is very great, the amount of heat given out by the union of the ignited carbon with hydrogen is so small as to be scarcely appreciable, or rather to be inappreciable except as a matter of inference. Hence it results that if we burn some ignited charcoal in hydrogen, the amount of heat evolved by its combination with the hydrogen will nothing like suffice to retain it at the temperature requisite for its combination, whence all action whatever will quickly cease, and the charcoal become extinguished or go out. The only way then for us to effect the combination of carbon with hydrogen, is for us not only to make the charcoal intensely hot, but further to keep it hot; as we are enabled to keep it by means of a powerful voltaic current. When kept in this way intensely hot, it enters into combination with the surrounding hydrogen, undergoing a sort of slow burning in the hydrogen. With regard to the products formed by the direct union of carbon with hydrogen, it would appear that the compound produced in the first instance is the primary hydrocarbon, marsh gas CH_4, although indeed this has not been proved to demonstration. But among the compounds actually met with is acetylene C_2H_2, a well-known product of the decomposition of marsh gas by heat. This acetylene is an important luminiferous constituent of ordinary coal gas, and is indeed the most luminiferous of its truly gaseous constituents. But acetylene, when submitted to a high temperature, has itself the property of undergoing a further change, and of being transformed into a volatile liquid, benzole, composed of carbon and hydrogen united in the same proportion as in acetylene:

$$3\,C_2H_2 = C_6H_6.$$

Accordingly, when passed through a red-hot tube or otherwise strongly heated, gaseous acetylene becomes largely transformed into condensable benzole, a body, by virtue of its condensability, of far less value than acetylene as a constituent of coal gas, and deposited in large measure from the gas, so as to become a constituent of the tar.

A word or two with regard to the combustion or burning of the hydrocarbons in air or oxygen. We have seen that when hydrogen and carbonous oxide burn, they simply enter into union with oxygen to form each a single oxidized product; but in the case of the hydrocarbons, two oxidized products

are furnished, or the constituents of the hydrocarbon undergo a simultaneous separation from each other and combination each with oxygen, thus:

$$CH_4 + O_4 = CO_2 + 2H_2O.$$

In the combustion, then, of the hydrocarbons, we have a balance of the two actions, combination and decomposition—that is to say, we have a small cooling effect consequent on the separation of the carbon and hydrogen from each other, and a largely preponderating heating effect consequent on the union of the separated carbon and hydrogen with oxygen. Thus, you perceive, the burning of the hydrocarbons is a phenomenon of a somewhat different nature from the burning of the simpler constituents of coal gas that we have previously referred to.

We now proceed to discuss the combination of carbon with sulphur, and to consider the nature of the product furnished by the combination. You know that chemists are in the habit of associating together sulphur, hydrogen, carbon, and the metals, as belonging to the class of combustible bodies, whereas oxygen is referred to the opposite class of empyreal or combustion-supporting bodies. But we shall find that hydrogen, carbon, and the metals are capable of burning in sulphur as in oxygen; and that although with respect to oxygen, sulphur is a combustible body, with respect to hydrogen and carbon it is truly a combustion-supporting or empyreal body. And, indeed, notwithstanding that sulphur is an opaque yellow solid and oxygen a colourless invisible gas, there is more of real analogy between these two elements than subsists between hydrogen, carbon, and the metals; and to such an extent does the analogy prevail, that by far the great majority of oxidized compounds are capable of being represented by similarly constituted and characterized sulphurized compounds. Thus, sulphuretted hydrogen H_2S, is only a sulphurized representative of water H_2O, and sulphide of carbon CS_2, a sulphur representative of carbonic acid CO_2. No sulphur compound, indeed, corresponding to carbonous oxide has hitherto been produced; but the existence of an oxisulphide of carbon, intermediate between sulphide of carbon and carbonic acid, seems to be well established:

$$CS_2;\ COS;\ CO_2.$$

Sulphur, when heated out of access of air, melts at about 239° Fahr., and boils at 836° Fahr., yielding a heavy orange-red vapour. Hydrogen and many of the metals burn in this vapour, under conditions similar to those under which they burn in oxygen; although, indeed, the combustion of the metals, and more particularly of iron, does not take place readily unless they are either in a fine state of division, or at an exceedingly high temperature. Thus, while sulphur is habitually distilled from heated iron pots, a strongly heated iron poker will burn in sulphur vapour as readily, and with almost as much brilliancy, as in oxygen gas. With regard to carbon, if we take a piece of carbon or charcoal, and having made it red hot, introduce it into a vessel of sulphur vapour, the charcoal enters into combination with the sulphur, and as a result of the combination, an appreciable amount of heat is evolved; but the amount of heat evolved is quite insufficient to maintain the charcoal at the temperature requisite for the combination or combustion to go on, and the action accordingly soon comes to an end. It is only when the charcoal, having been heated to bright redness, is kept at the temperature of bright redness by external means, that its combination with the sulphur vapour is continuous. Hence the method adopted for the commercial production of sulphide of carbon--and it is now produced on an extensive manufacturing scale—consists in passing the vapour of sulphur over ordinary coke kept strongly heated in fire-clay cylinders. With regard to the occurrence of sulphide of carbon as a constituent of coal gas, supposing the sulphur of the coal actually existed in the state of free sulphur, it is doubtful whether at any stage of the distillation, the conditions necessary for the production of sulphide of carbon would prevail. If formed at all in the early stages of the distillation, it would be in the presence of other compounds, with which it speedily undergoes double decomposition. And so long as the temperature of the interior of the retorts is appreciably kept down by the continuance of the distillation, a sufficient degree of temperature to allow of the carbon and free sulphur entering into combination with each other, could hardly be reached. And independently of this, the sulphur would be distilled off with the other volatile products of the

coal, long before the high degree of temperature necessary for its conversion into sulphide of carbon could be attained. You will remember that the temperature at which sulphur boils is 836° Fahr. Now, the temperature of a dull red heat, just visible in the dark, is usually put down at 1000° Fahr. But for carbon to enter freely into combination with sulphur vapour, a temperature falling not far short of 1500° or 1600° would probably be required. So that if the sulphur of coal existed simply in the form of free volatilizable sulphur, very little risk of the formation of sulphide of carbon would be incurred in the process of gas manufacture. And the smallness of the risk may be illustrated in this way:—If you take a mixture of sulphur and of carbon, in the form either of coke or charcoal, and heat the mixture in any suitable vessel, you will find the sulphur distil off, and the carbon be left behind unacted on.

But, as a matter of fact, the sulphur of coal does not exist in the form of free volatilizable sulphur, but chiefly in the form of the fixed mineral substance, iron pyrites. Now, iron pyrites, though troublesome to gas-makers as a constituent of coal, is by itself a very important and valuable material—so much so indeed, that during the year 1871 there were nearly half a million tons of it consumed in this country for the production of sulphuric acid or oil of vitriol, in its various forms. Iron pyrites is a combination of iron with sulphur. When used for manufacturing purposes, it is simply set fire to. Like gas-carbon or hard coke, a single piece of it does not burn very readily, but in large quantities it forms by itself a very good fuel. Its sulphur burns into sulphurous acid, which is conveyed by suitable flues into large leaden chambers, wherein it is converted into sulphuric acid; and its iron burns into a residue of iron oxide, which is now-a-days further treated, so as to yield a variety of valuable products.

But the point we have specially to consider is not so much what happens when pyrites is heated in a draught of air so as to burn, but what happens when the pyrites is heated strongly in close vessels, either alone or in contact with carbon. Now, iron pyrites by itself, will stand a very considerable degree of heat without undergoing any obvious change. But at a full red heat it melts, and at a little higher temperature it gives off one-third of its constituent sulphur, so as to leave a residue having the composition of magnetic pyrites. Iron pyrites being constituted of one proportion or 56 parts by weight of iron, and two proportions or 64 parts by weight of sulphur, every 100 lbs. weight of pyrites evolves at a full red heat 21 lbs. of sulphur, and that under conditions most favourable for its entering into combination with carbon:

$$3FeS_2 = Fe_3O_4 + S_2.$$

But even this is not all; for at a full red heat, the pyrites melts and sinks into the porous coke, for instance, with which it may be in contact; so that we have to consider not merely the effect of a strong heat upon pyrites, but its effect upon an intimate mixture of pyrites and carbon. And in this case, the pyrites gives off not merely one-third but one-half of its sulphur, so as to leave a residue of protosulphide of iron, thus:

$$2FeS_2 + C = 2FeS + CS_2.$$

Indeed, instead of strongly heating carbon in an atmosphere of sulphur vapour, a very good laboratory process for producing sulphide of carbon consists in heating strongly a mixture of pyrites and carbon. The protosulphide of iron resulting from the reaction is a common constituent of ordinary gas coke, and it is to the presence of this constituent that the evolution of some sulphuretted hydrogen, on quenching the strongly-ignited coke with water, is due. I do not call to mind any precise experiments upon the subject, but there is, I believe, little doubt that the chief proportion of sulphide of carbon found in coal gas, is produced in the later stages of the distillation. Doubtless, also, it is produced in the manner I have just explained, by a reaction of the pyrites with the first formed and most strongly heated coke.

We have next to consider the properties of sulphide of carbon. In the first place it is a combustible body, and burns with a characteristic blue flame. Its burning, like that of the hydrocarbons, is a complex phenomenon. We have a simultaneous separation of the carbon and sulphur from each other, and an oxidation of them into carbonic acid and sulphurous acid gases respectively; or

each constituent yields the same burnt product that it would yield if burnt by itself in the free state:

$$CS_2 + O_6 = CO_2 + 2SO_2.$$

When, however, the supply of air is insufficient, a portion of the sulphur escapes being burnt, and the reaction then takes place in this way:

$$CS_2 + O_4 = CO_2 + SO_2 + S.$$

But it is important to bear in mind that, however much air you may supply, or even if you substitute oxygen for air, the sulphur burns simply into the comparatively innocuous sulphurous acid SO_2—the strict chemical anologue of carbonic acid CO_2—and that to effect the conversion of this sulphurous acid into the far more objectionable sulphuric acid, a further and distinct operation is required.

Sulphide of carbon occurs as an exceedingly mobile liquid, devoid of any viscidity, and, when perfectly pure, is as colourless and transparent as water. As usually met with, however, it has more or less of a yellowish or brownish tint. It is a highly refractive and dispersive substance, and accordingly, when viewed in certain lights, is apt to exhibit a brilliant glow of prismatic colours. The extremely nauseous odour presented by most specimens of sulphide of carbon is consequent on their impurity. When thoroughly purified, sulphide of carbon, has a by no means unpleasant odour. Its proper smell, without indeed being quite so agreeable and fruity as that of chloroform, is very similar thereto. Here is a specimen of sulphide of carbon which, from its smell alone, might readily be taken for a specimen of chloroform. It is further a very heavy liquid, having a specific gravity of 1·27, and being consequently more than 1¼ times as heavy as water, with which moreover it is immiscible; so that when I pour some sulphide of carbon into this tall cylinder of water it falls to the bottom as a distinct layer of liquid. Indeed it is only just sufficiently soluble in water to import a taste and smell thereto. But sulphide of carbon, though insoluble in water, is capable of mixing in all proportions with alcohol and ether. If I pour into this cylinder of alcohol some disulphide of carbon, the greater part of it disappears before reaching the bottom, and the whole of it disappears after a moment's agitation. This solubility of the disulphide in alcohol is taken advantage of by chemists when they wish to subject it to the action of chemical agents, and more particularly to the action of alkalis. If we take an aqueous solution of potash or ammonia, and agitate some disulphide of carbon therewith, the sulphide of carbon being insoluble in the water, is almost unaffected by the dissolved alkali, with which indeed it is scarcely brought into contact. But if instead of an aqueous we take an alcoholic solution of potash or ammonia, in which the disulphide dissolves readily, by the act of solution every particle of it is brought into contact with and acted on by the dissolved alkali. And indeed if alcohol were as little costly as water, we should find no great difficulty in dealing with the sulphide of carbon contained in our coal gas.

Independently of its power of mixing with or dissolving alcohol and ether, sulphide of carbon is a powerful solvent of various other inflammable highly carbonaceous bodies, as caoutchouc, resins, fats, essential oils, &c., and, indeed, it is chiefly on account of its solvent action on this class of bodies that it is now so largely manufactured. It has the further property of dissolving certain of the non-metallic elementary bodies, and more particularly iodine, sulphur, and phosphorus. On taking this stick of phosphorus, for instance, and introducing it into a narrow bottle of disulphide of carbon, you will see the stick of phosphorus disappear far more quickly than a stick of barley-sugar would disappear in water.

The solvent power of sulphide of carbon for iodine, giving rise to the production of a deep crimson or purple liquid, is also very characteristic. Here you perceive the splendid colour imparted to the disulphide by my adding a little iodine to it. It has, moreover, the power of removing iodine from its solution in water; so that if I add a little tincture of iodine to the water overlying the disulphide in this cylinder, and then agitate the entire contents, the iodine leaves the water to become dissolved in the sulphide of carbon, which accordingly acquires a bright pink colour; and this acquisition of a pink tint by sulphide of carbon, when agitated with an aqueous solution, constitutes a very delicate test for the presence of free iodine in the solution.

Sulphide of carbon has also a marked solvent action on sulphur; and only a few years back, it was conceived by some ingenious person that, inasmuch as sulphur was dissolved by liquid disulphide of carbon, disulphide of carbon vapour ought to be absorbed and retained by sulphur; and it was even proposed to free coal gas from sulphide of carbon by passing the gas over sulphur, that had been melted on crumpled wire, so as to expose a large surface to the gas. But it does not at all follow, because a solid substance is soluble in some particular liquid, nitre in water for example, that therefore the solid should be absorptive of the vapour of the liquid, as salt of tartar, for instance, is absorptive and retentive of moisture. As a matter of fact, sulphur is not absorptive of disulphide of carbon vapour; and, even if it were so, the process of passing coal gas over finely-divided sulphur is practised at all gas-works, where revived oxide of iron, charged necessarily with a greater or less proportion of sulphur, is used in the purifiers.

I now want to call your attention to some properties of disulphide of carbon, which are of importance in relation to our power, or rather want of power, of removing this impurity from coal gas. One of these properties is its extreme volatility. The boiling point of water being 212° Fahr., that of disulphide of carbon is 117° Fahr. only. Accordingly, on surrounding a flask of the disulphide with hot water, violent ebullition is set up; and the vapour rushing out from the mouth of the flask, takes fire on my bringing a light to it, and burns, as you perceive, with a characteristically blue flame. But a point of more interest to us than its low boiling point is its extreme volatility at ordinary temperatures. On dropping a small thin bulb of disulphide of carbon into this large bottle of air, and shaking up the bottle, the contained air becomes charged with the vapour of the disulphide, set free by the breaking of the bulb, to such an extent as to become readily and permanently inflammable. And I may associate this demonstration of the ready volatility of sulphide of carbon, with a demonstration also of the great weight of its vapour. Thus I am able to pour out the air, charged with sulphide of carbon vapour, into this iron tray, and there set fire to it. Here again I have an inclined wooden trough about eight feet long, and a beaker-glass containing some liquid sulphide of carbon. I incline the beaker a little, so as to allow the vapour it contains to flow over into the trough, down which it then gradually descends, by reason of its great weight, till it reaches the bottom, where its presence is manifested to you by its catching fire from the spirit lamp flame with which it there comes into contact. Carbonic acid gas being one and a half times heavier than air, sulphide of carbon vapour is more than two and a half times heavier.

I may avail myself also of the ready volatility of disulphide of carbon to illustrate to you the extremely low temperature at which its vapour is capable of being inflamed. I pour a few drops of the disulphide into this small cylinder, and then introduce the end of a glass rod, which has been gently heated by being held at some distance above an Argand flame; and directly on its coming into contact with the heated rod, the vapour in the cylinder at once takes fire. Indeed, a temperature below 400° Fahr. is sufficient to effect, the inflammation of disulphide of carbon vapour. And a distinguished friend of mine has contended that the presence of the small proportion of disulphide of carbon vapour usually found in coal gas, is objectionable on account of its rendering the gas too easily inflammable. But it appears to me, that this objection is quite untenable, and altogether opposed to the experience of any of us who may have tried to light a jet of ordinary coal gas, however highly charged with sulphide of carbon, either with a gently heated glass rod or yet with a red hot poker.

The extreme volatility of disulphide of carbon, even at very low temperatures, accounts satisfactorily for the impossibility of our removing it from coal gas by any practicable process of condensation. Indeed, by cooling down any gas, you only cause a deposition of the excess of vapour in it beyond that which it can retain at the temperature to which it is cooled down. But coal gas, which could contain as much as one-fifth of its volume of disulphide of carbon vapour at 55° Fahr. and one-seventh of its volume of the vapour at 32° Fahr., is of course never charged to anything like saturation. Accordingly, little is to be hoped for in the way of the removal of sulphide of carbon from coal gas, by its mere condensation. You do indeed remove some of it, by reason of the tarry products deposited carrying down some

disulphide of carbon with them; but from an otherwise pure gas, no practically attainable degree of cooling would effect any removal of disulphide of carbon whatever.

I may give you one or two further illustrations of the ready volatility of disulphide of carbon. Here is the solution of phosphorus in disulphide of carbon that we prepared a few moments ago. On pouring a little of this solution on a sheet of paper, the disulphide of carbon quickly evaporates altogether, leaving upon the paper nothing but a film of phosphorus, which, offering a large surface to the air, quickly undergoes oxidation, and bursts into flame. And, lastly, I may give you an illustration both of the low temperature at which the disulphide evaporates, and of the low temperature produced by its evaporation. On the top of this small stool I pour a little water, and stand upon the wetted stool a beaker containing some disulphide of carbon. On blowing into the beaker with an ordinary pair of bellows, evaporation of a portion of the disulphide is effected, whereby the temperature of the remainder is reduced considerably; but, so long as any is left, it continues to volatilize. And now that the whole of it is volatilized, we observe the beaker to be sufficiently cold to have become frozen firmly to the stool, the intervening layer of water having been changed into a layer of ice.

Now, just as there is a difficulty in removing sulphide of carbon vapour from coal gas by condensation, so also is there a difficulty in removing it by washing. Indeed, it is so insoluble in water that we have no chance whatever of effecting its removal by scrubbing the gas with water. I take for convenience sake, a bottle, not of coal gas, but of air, and add thereto a few drops of disulphide of carbon; and you see that, by reason of the amount of disulphide of carbon vapour thus diffused through it, the air is rendered inflammable. I now half fill the bottle with water, and shake up its contents violently so as to effect a thorough washing of the air it contains; but that I have not thereby removed any appreciable quantity of the disulphide vapour is shown to you by the air still continuing inflammable.

With regard to the purely chemical properties of disulphide of carbon, the most interesting and important are those which it manifests with the caustic alkalis, but the consideration of these we will put off for a little while. A reaction of disulphide of carbon of some interest, by which indeed its presence in coal gas was first unmistakeably demonstrated, is its reaction with the remarkable compound discovered by Hofmann, and known by the elaborate name of tri-ethyl-phosphine. You remember there was a time when it was doubted whether the sulphur (other than sulphuretted hydrogen) existing in coal gas, was sulphide of carbon at all—whether it might not be some different unrecognized compound of sulphur instead. Now, the tri-ethyl-phosphine resorted to for the decision of this question, is a very difficult substance to prepare; like disulphide of carbon, it is a volatile substance, giving off vapour at ordinary temperature, and, when its vapour is mixed with air, a very slight increase of temperature is sufficient to cause the inflammation or explosion of the mixture. Thus I take here a piece of blotting-paper, which I wet with a few drops of the tri-ethyl-phosphine, and then place in a wide test-tube. The test-tube thus contains a mixture of air and tri-ethyl-phosphine vapour, and on now standing the tube for a minute in some warm water, you perceive we have at once an explosion. Now this tri-ethyl-phosphine, which the experiment I have just shown you indicates to be a somewhat dangerous substance to deal with, has the property of uniting with disulphide of carbon to form a well characterized orange crystallized solid. You see, on my adding a few drops of the disulphide to a little of the tri-ethyl-phosphine, a violent reaction takes place, and we get the orange compound produced. Now this same compound is produced when a current of coal gas is led slowly through tri-ethyl-phosphine, and its production of course establishes the existence of disulphide of carbon in the gas. But it does not at all follow that because some of the sulphur (other than sulphuretted hydrogen) occurring in coal gas exists in the form of sulphide of carbon, that therefore the whole of it exists in that form. From certain considerations, indeed, it would appear probable that the vapour of more than one sulphur compound exists in coal gas; although doubtless disulphide of carbon is the principal form in which the sulphur occurs.

I will next call your attention to the reaction, at a moderate heat, of disulphide of carbon vapour and hydrogen gas. This reaction is of interest as having been made by Mr. Vernon Harcourt the basis of a suggested means for effect-

ing the removal of sulphur from gas. If you take either hydrogen or coal gas, which latter contains, you will remember, a large proportion of free hydrogen, and charge the one or the other with sulphide of carbon vapour, and then subject the mixture to a moderate heat, this result will be attained, that the sulphur which existed at first in combination with carbon, that is, in a form in which it cannot be removed by ordinary means, is caused to enter into combination with hydrogen, and so to exist as sulphuretted hydrogen—in a form I need scarcely say in which it can be readily enough removed. I can show you two experiments that illustrate this reaction. In the first, some pure dry hydrogen gas is passed over a little disulphide of carbon so as to acquire some of the vapour, then over lead paper to show its freedom from sulphuretted hydrogen, then through a gently heated glass tube, and then over some other lead paper, which you observe quickly becomes blackened, evidencing to you the formation of some sulphuretted hydrogen as a product of the decomposition of the disulphide of carbon taken up. In the other experiment we are passing ordinary coal gas, first over some lead-paper to show its freedom from sulphuretted hydrogen, then through a gently heated iron-tube to effect the decomposition of its disulphide of carbon, and lastly over some other lead-paper to show the production of sulphuretted hydrogen by the reaction. The nature of the reaction by which the sulphur, from being in the unmanageable form of sulphide of carbon, is obtained in the manageable form of sulphuretted hydrogen, is probably as follows :—

$$CS_2 + H_8 = CH_4 + 2H_2S.$$

That the process is thoroughly successful on a small scale has been demonstrated; and Mr. Harcourt is convinced that it would also prove successful on a manufacturing scale, and that it could moreover be practised without effecting any deterioration in the illuminating power of the gas. The uniform heating or reheating of any considerable body of air or gas has usually, however, proved a matter of some little difficulty in practice.

There is yet another reaction, taking place, I think, at a rather lower temperature, whereby the sulphur of coal gas, other than sulphuretted hydrogen, is converted into the form of sulphuretted hydrogen. This is a somewhat old story, which attracted a good deal of attention at the time when Mr. Bowditch brought forward his process of gas purification some years ago. When sulphide of carbon vapour in presence of water (either in the form of steam, or as the water of combination existing in slaked lime) is subjected to a gentle heat, a reaction takes place whereby, instead of having sulphide of carbon and oxide of hydrogen, we obtained oxide of carbon or carbonic acid gas, and sulphide of hydrogen or sulphuretted hydrogen gas, both products readily removeable by the ordinary processes of purification :

$$CS_2 + 2H_2O = CO_2 + 2H_2S.$$

This process of passing coal gas over heated slaked lime was practiced, I believe, for some time at the Wakefield Gas-Works, but not with such satisfactory results as to lead to any general adoption of the process. The difficulty was that for the reaction to place take at all completely, the gas had to be passed very slowly over the slaked lime, so as to remain in contact with it for a considerable time—for a greater time, indeed, than could be afforded in the course of the manufacture. Still it is a point worthy of being known by gas managers, that if you have steam and sulphide of carbon present together at a moderate heat, in the course of a little time they do react, with conversion of the sulphur of the sulphide of carbon into the form of sulphuretted hydrogen; and it being admitted that by far the larger proportion of the sulphur found in coal gas is produced at the latter stage of the distillation, and chiefly from the strongly heated and thoroughly coked charge in contact with the floor of the retort, it is certain, I think, that if at this stage of the distillation, a small quantity of steam could be in any way introduced or produced within the retort, all sulphide of carbon would be destroyed as soon as formed. As an illustration, I have here a small iron tube which contains a mixture of pyrites and coke—that is, such a residue as would be left by the distillation of a coal, rich in

sulphur. The tube being heated to redness, I now pass a very small current of steam through it, and you see by the instantaneous and complete blackening of the lead solution, what an abundance of sulphuretted hydrogen we are in this way producing, with, of course, correlative destruction or non-production of sulphide of carbon

I am now about to call your attention to the relationship subsisting between disulphide of carbon CS_2, and carbonic acid gas CO_2. You know that when ordinary limestone is strongly heated, it breaks up into carbonic acid gas or oxide of carbon, and caustic lime or oxide of calcium :

$$CaCO_3 = CaO + CO_2.$$

But practically, at any rate, you cannot reproduce limestone or chalk by bringing together its constituents in the anhydrous, dry state. Instead of quicklime you have to use slaked lime or hydrate of calcium, and even then the action takes place but slowly, unless you facilitate it by employing your slaked lime in a slightly moistened condition. And this is only one instance out of many of the advantage, or even in some cases the necessity, of the intervention of moisture, where a soluble gas and a solid are required to act upon each other. Thus, with dry air and dry iron, there is entire freedom from rusting, but with the surface of the iron moistened, an absorption of the oxygen of the air takes place, and rust is very quickly produced. But in respect of the removal of disulphide of carbon from coal gas by means of any chemical absorbent, owing to the insolubility in water of the disulphide, we gain nothing, probably we lose something, by employing our absorbent moist; or we have to forego in the case of the difficultly removeable sulphide of carbon, the advantage we are so glad to avail ourselves of in the case of the readily removeable carbonic acid and ammonia. And, of course, this insolubility of the disulphide in water interferes very seriously with the removal of its vapour by means of absorbents dissolved in water, and used in scrubbers or wet purifiers, as I have, indeed, already remarked. But despite the difficulty consequent on its insolubility in water, there are agents capable of removing sulphide of carbon from coal gas, provided the gas is allowed to remain in contact with them for a sufficient length of time.

I would remind you, again, of the analogy subsisting between sulphur and oxygen. You know, for instance, that chalk is called by chemists carbonate or oxicarbonate of calcium, $CaCO_3$. Now, there exists another compound called by chemists sulphocarbonate of calcium, $CaCS_3$; and just as chalk or oxicarbonate of calcium is capable of being produced by the action of carbonic acid gas CO_2, on hydrate or oxihydrate of calcium $CaO.H_2O$—fresh slaked lime,—so is sulphocarbonate of calcium capable of being produced by the action of sulphide of carbon, CS_2, on sulphydrate of calcium, $CaS.H_2S$, the chief constituent of half-foul gas lime :

$$CaO.H_2O + CO_2 = CaO.CO_2 \text{ or } CaCO_3 + H_2O$$

$$CaS.H_2S + CS_2 = CaS.CS_2 \text{ or } CaCS_3 + H_2S.$$

Gas lime, then, in a particular state of foulness to which I shall refer more particularly in a minute or two, has the property of absorbing sulphide of carbon, much as slaked lime has the property of absorbing carbonic acid; though even under the most favourable circumstances the action is far more sluggish, and though, in practice, the circumstances never are so favourable, owing to our not deriving in the case of the disulphide that advantage from the employment of a moist absorbent, that we are accustomed to avail ourselves of in the case of carbonic acid. Further, just as carbonic acid may be absorbed equally well by some other hydrated alkali instead of by hydrated lime, so may disulphide of carbon be equally well absorbed by some other sulphydrated alkali instead of by sulphydrated lime. But it is obvious that the only sulphydrated alkali that can at all compete in point of cheapness with sulphydrated lime, is the sulphydrated ammonia always existing to some extent, and capable of being accumulated to a large extent in gas liquor. Sulphide of carbon, then, combines with sulphydrate of ammonia, $NH_3.H_2S$—more conveniently regarded as sulphydrate of ammonium, $(NH_4)HS$—to form the body sulphocarbonate of ammonium, $(NH_4)_2CS_3$, analogous to sulphocarbonate of calcium, $CaCS_3$, or, more strictly, to sulphocarbonate of potas-

sium, K_2CS_3—two proportions of ammonium or potassium being equivalent to one proportion of calcium, thus:

$$\begin{array}{rlll} & CaS.\ H_2S + CS_2 = & CaS.\ CS_2 \text{ or} & CaCS_3 + H_2S \\ 2\ KHS \text{ or} & K_2S.\ H_2S + CS_2 = & K_2S.\ CS_2 \text{ or} & K_2CS_3 + H_2S \\ 2\ (NH_4)HS \text{ or} & (NH_4)_2S.\ H_2S + CS_2 = & (NH_4)_2S.\ CS_2 \text{ or} & (NH_4)_2CS_3 + H_2S. \end{array}$$

Now, this sulphocarbonate of ammonium or of ammonia, which may also be written as $N_2H_8CS_3$, is a very unstable body. In presence of an excess of ammonia, it loses sulphuretted hydrogen to become converted into a new salt, sulphocarbamate of ammonia $N_2H_6CS_2$; which again, in presence of a further excess of ammonia, loses more sulphuretted hydrogen to become converted into sulphocyanate of ammonia N_2H_4CS; and you know how commonly deposits of this sulphocyanate of ammonia occur, in cases where the gas is left ammoniacal:

$$N_2H_4CS = (NH_4)CNS = (NH_3)HCNS.$$

But, although sulphide of carbon is absorbed most readily by sulphydrated alkali, caustic alkali is not altogether without action on it; and, provided the caustic alkali be dissolved in spirit of wine, the action is very prompt indeed. But the introduction of the spirit of wine leads to the formation not of a simple sulphocarbonate, but of a complex ethereal salt known as a xanthate. Sulphocarbonate of potassium being represented by the formula K_2CS_3, there is a corresponding ethereal salt known as ethyl-sulphocarbonate of potassium $(C_2H_5)KCS_3$, which differs only from the salt produced by the absorption of disulphide of carbon in alcholic solution of potash, or xanthate of potassium $(C_2H_5)KCOS_2$, by containing three proportions of sulphur instead of two proportions of sulphur and one proportion of oxygen. This xanthate of potassium is a crystalline salt, and may be produced in any quantity with the greatest ease, by the simple mixture together of alcohol, caustic potash, and disulphide of carbon, thus:

$$(C_2H_5)HO + HKO + CS_2 = H_2O + (C_2H_5)\ KO.CS_2 \text{ or } (C_2H_5)KCOS_2.$$

I can illustrate to you the formation of this salt very readily. I take some spirit of wine or alcohol, dissolve in it a little caustic potash, then add to it some disulphide of carbon, and agitate the whole for a minute or so. The xanthate is now formed; and on pouring out a little of the liquid into water, and then adding some sulphate of copper solution, I get thrown down the characteristic orange-yellow precipitate of xanthate of copper, from the production of which the acid acquires its name of xanthic, meaning yellow. Now if you take ordinary coal gas and pass it slowly through an alcoholic solution of caustic potash, you will find the gas to be deprived in great measure of its sulphur, and xanthate of potassium to be formed in the liquid. And the formation of xanthate of potassium under these circumstances, will be another evidence to you of the existence of the sulphur contained in the original gas, in the form of disulphide of carbon.

But in practice, we cannot, of course, resort to alcoholic potash as a purifying agent, but must content ourselves with sulphydrated ammonia or sulphydrated lime, that is to say, with gas liquor or foul lime in a particular condition; and, having been consulted by certain gas companies, to help them out of the difficulty they were in with regard to the large proportion of disulphide of carbon which continued to exist in their gas, despite every attempt to effect its reduction, my attention has of late been especially directed to the subject of sulphur purification; and I believe I am now in a position to point out to you the proper mode of using the agents of which I have just spoken, so as to produce a uniformly beneficial result. You are aware that trials and experiments out of number, and in ways the most various, have been made in the use of both lime and gas liquor, to effect the desulphuration of gas; and that, although at times and places, some of these trials have led temporarily to most satisfactory results, they have not resulted in the introduction of any definite method of procedure which could be constantly and everywhere relied upon. Now the essence of the method which I was led to suggest, and which has furnished excellent esults in practice, consists in treating the gas for its disulphide of carbon in

a distinct set of purifiers charged with sulphydrated lime, carefully maintained in the sulphydrated state by the previous removal of all carbonic acid from the gas in an initial set of clean lime purifiers, and supplemented by a subsequent removal of sulphuretted hydrogen from the gas in a final set of oxide purifiers. This recommendation agrees in substance with that of the gas referees, than which, however, it goes a little further. It was made, however, without knowledge of the results and conclusions of the referees, and indeed a few days before the publication of their very able and complete report.

In unpurified coal gas, there are three substances of an acidulous character present, namely, carbonic acid, sulphuretted hydrogen, and sulphide of carbon. Of these three, carbonic acid, though indeed but a weak acid, is alike the most strongly acidulous and the most abundant. If then, you pass your gas over slaked lime or through caustic ammonia, so long as the alkali is in considerable excess it will absorb not only the carbonic acid, but also sulphuretted hydrogen, and jointly therewith some disulphide of carbon. But this last action, partial at the best, soon becomes insignificant. To effect by means of alkali, the continuous removal of the least chemically active and least abundant of the acid impurities, you must take away the most active and abundant of them first. You must make the complete removal of the carbonic acid from your gas an object of primary importance, and effect its removal as a separate operation; not so much because of any objection to its retention in the gas delivered, as because of its non-removal interfering with the efficient removal of the sulphide of carbon. The process of purification then, which I was led to recommend to those who consulted me, and which I now recommend to you, consists of three operations:—

1. The gas from the scrubbers, should first be purified completely from carbonic acid, by being passed continuously through three out of four lime purifiers in the usual manner; putting the fourth purifier into the series, and throwing out the first purifier, whenever the gas from the outlet of the second purifier produces a decided effect on lime water.

2. The completely decarbonated gas should next be treated with a view to remove from it its sulphur, not in the form of sulphuretted hydrogen. With this view, it should be passed through another set of purifiers, charged with lime that is left unchanged for weeks and even months together. The hydrated lime in these purifiers, by its union with the remaining sulphuretted hydrogen of the decarbonated gas, will quickly become converted into sulphydrated lime, and will remain in the form of this compound for an indefinite period, provided only that the gas passed over it is first completely and continuously decarbonated. Notwithstanding the small actual quantity of impurity to be removed by these purifiers, they should be of full size, so as to allow time for the somewhat sluggish action between the sulphide of carbon and sulphydrated lime to take place in them.

3. The gas, after having been completely freed from carbonic acid, and treated for the removal of sulphide of carbon by being transmitted through sulphydrated lime as above described, should finally be freed from sulphuretted hydrogen, by being passed through three out of four oxide of iron purifiers in the usual manner.

Instead of being treated firstly with caustic lime frequently renewed, to remove the carbonic acid, and secondly with caustic lime renewed as seldom as possible, to remove the sulphide of carbon, I have no doubt that equally good results might be obtained by treating the gas, firstly with caustic ammonia frequently renewed, to remove the carbonic acid, and secondly with caustic ammonia renewed as seldom as possible, to remove the sulphide of carbon; though with regard to the success of this modification of the process, I cannot speak from experience. The caustic ammonia for the purpose might be obtained from gas liquor, by Mr. Hills' very ingenious process, which has been put in practice by Mr. Livesey at the South Metropolitan works, I believe with complete success. I do not know whether cleansing gas with caustic lime or caustic ammonia would prove in practice the most economical and otherwise advantageous. This I leave to you; as also any variation in the details of the mode of proceeding I have just described. I profess only to explain to you the chemical conditions necessary for the removal by m eans of caustic alkali, of sulphide of carbon, jointly with some sulphuretted hydrogen from coal gas.

WEDNESDAY, JUNE 12.

The PRESIDENT took the chair this morning at eleven o'clock.

Mr. G. ANDERSON (London) read the following paper

ON THE CHEAPEST AND BEST MEANS OF ABSTRACTING AMMONIA.

Gentlemen,—I appear before you again to read a paper on the purification of gas from ammonia because the council requested that I should do so.

You will find that I read a paper on this subject before the society at its meeting in Nottingham in 1867.

I apprehend that the reason why the council have this year requested a paper on the same subject is due to the increasing importance of the question, both as a sanitary one in the improvement of the gas, as well as in its commercially beneficial results to gas companies.

There is another reason, however, which to my mind renders a paper on this question peculiarly appropriate this year, because we have had a very elaborate report on this particular point from the London Gas Referees since our last meeting, and published in the JOURNAL OF GAS LIGHTING of the 29th of August last; and before proceeding to the matter more germane to this paper, I desire to say a few words on that report.

From a perusal of that report it appears that the referees found several of the London gas companies supplying gas impure as regards ammonia. It also appears that they found many of the scrubbers of defective construction, both from the fact of the scrubbing material being in a continuous mass, and not relieved by being placed in separate layers on shelves, as also from the apparatus for distributing, the liquid used being of an imperfect kind; and they give recommendations for remedying those defects; they also, in the summary of their proceedings, state that the statistics they have furnished will be interesting on public grounds, and of practical value to gas companies and their engineers, and I have no doubt they will.

But in the interest of the profession to which I belong, I beg to state that there is no fact or recommendation in their report that is not well known to many gas engineers, and have been acted upon in the construction of gas-works, and that from the published proceedings of this society all that is good in their report may be found.

It is not my wish in any way to detract from the merits of that report. It is a very valuable report, and will repay perusal by any one interested in the subject. I rose from the reading of it very much pleased, as much so as if I had written it myself, because it confirmed opinions that I have publicly expressed before you on controverted points, when I have impressed on you the desirability of purifying your gas; but, I said to myself, if this thing goes on, if those gentlemen of intelligence and resource, and paid for doing it, publish reports of this kind, they and the Gas Managers Association will become competing bodies. We have years ago recorded in the transactions of our society the very facts on which they dwell as improvements which they are introducing into the London gas-works, and we, therefore, claim priority of knowledge of the facts, and also of the practical application of them, in proof of which I refer to the paper read before this society at Nottingham in 1867, on "The Extraction of Ammonia from Gas and the Utilization of the Products." But the propriety of purifying our gas from ammonia was recognized and acted on bp both George Lowe and Alexander Angus Croll, as London gas engineers, many years ago.

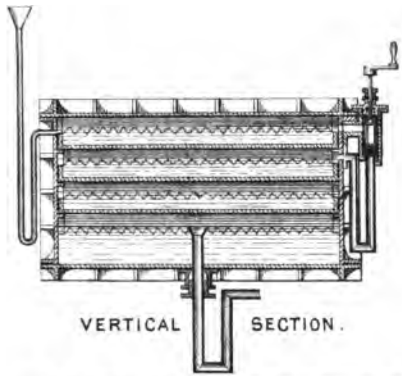
I have no doubt but the referees are not aware that more than 20 years ago the whole of the gas supplied by the Great Central and Surrey Gas Companies was absolutely free from ammonia. The former supplies the City of London, the latter a portion of the south side of the metropolis, and during the time that Mr. Croll, their lessee, had the conduction of the works, this state of purity remained.

They also may not be aware that George Lowe, five-and-twenty years ago, employed a scrubber with the contained matter in layers, the under half of which was washed with ammoniacal liquor, and the upper or finishing portion by clean water.

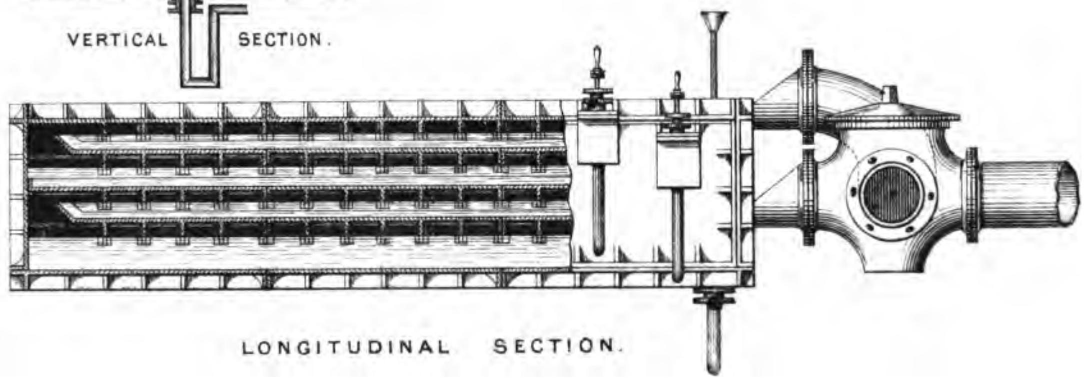
A drawing of this scrubber, used in my paper in 1867, is again placed on the wall.

The referees, in their report, confirm a statement I made to you in 1867—

ANDERSON'S SURFACE GAS WASHER.



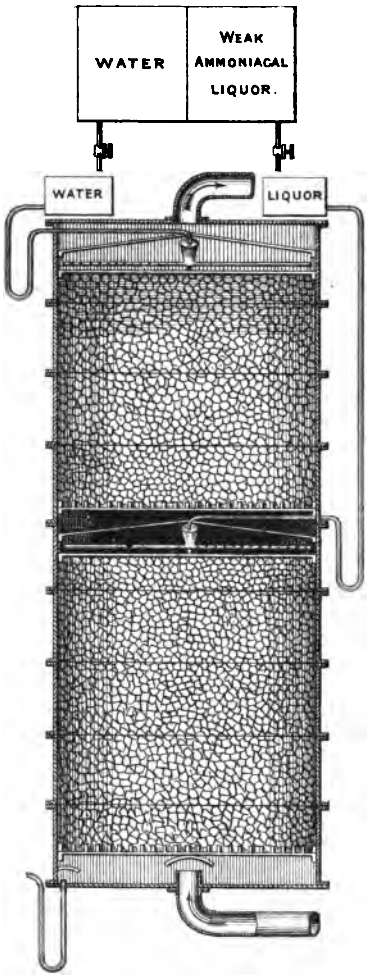
VERTICAL SECTION.



LONGITUDINAL SECTION.

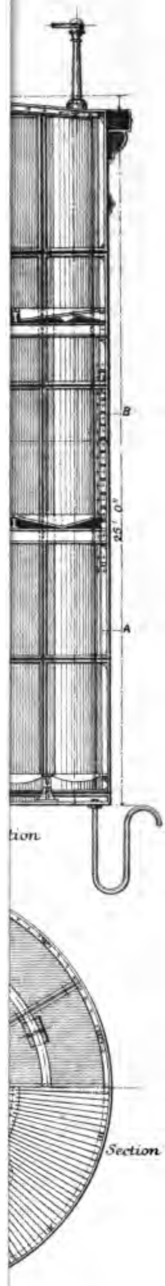
Litho Whiteman & Bass, 236, Holborn, London.

LOWE'S PATENT GAS WASHER.



VERTICAL SECTION,

SCRUBBER.



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namely, that clean water, used judiciously, does not injure the illuminating power of the gas, and they point to the desirability of a better system of distribution than generally exists, and recommend the revolving system of Mr. Mann. That these points have all been previously attended to, I claim your attention to an extract from my paper of 1867, and to the drawings and models that illustrated it.

The gas referees are an important body, they have vast interests committed to their care; without the slightest doubt, if they continue, they will improve the gas of London, and that improvement will be published over the world. Until, however, they publish something new, we of this society, composed chiefly of gas engineers from all parts of the country, must claim to have anticipated them in their researches; and I will further state that had the gas engineers of London joined us—most of whom have, from some cause, held aloof—they might have gleaned some information that would have brought their state of knowledge on a level with that of the rest of the country, and prevented them being caught asleep by a body, however intelligent, who do not pretend to anything more than to theorise on the subject.

Before passing from the referees report, I think a word of extenuation may be said for some of the London engineers having allowed their gas to pass to the public unpurified.

I do not think that it was so much want of knowledge as want of wakening up; they went to sleep under the 10 per cent. dividend clause; they had arrived at that happy state of development, while yet in a semi-chrysalis state, and the want of further motive to action prevented them getting developed beyond that stage of existence. The Legislature, I think, is to blame for this, in requiring that the dividend cannot go above 10 per cent. If the profits beyond 10 per cent. were to be divided in given proportions between the companies and the public, and the companies were to increase the salaries of the engineers as the profits increased, the referees would have found less ammonia in the gas, for ammonia means gold dust that is worth washing out; and it is to be expected that, from the attention which the subject of ammonia is now receiving, our London gas engineers will receive such an impetus as will send them rapidly to the front, where they will occupy the position they ought never to have receded from.

The discussions to which I have referred have very much cleared the subject of the doubt and uncertainty that formerly surrounded it. We have, therefore, a considerable amount of solid ground to stand on. From the papers and discussions of this society, we have established, and the same has now been confirmed by the report of the referees:—1. That it is right to extract the ammonia from gas; 2. That this may be done by the use of ammoniacal liquor and pure water; and, 3. That the quantity of water necessary to do this when properly applied, does not injure the illuminating power of the gas; and I may add that, unlike the other impurities that have to be removed from gas, while they are all a source of expense, ammonia extraction is a source of profit in all works of any magnitude.

This latter fact gives an additional interest to the question this year from the extraordinary and hitherto unprecedented and sudden rise that has taken place in the price of coal, of iron, of bricks—indeed, in the price of everything employed in the manufacture of gas.

In the report of the referees, they mention the use of washers and of scrubbers; but they do not seem to have met with, nor do they contemplate, the use of both machines at once on the same works. This is another point which I deem of some importance, for, by using the washer first and the scrubber last, I get the whole of the tar removed from the gas while it is passing through the washer, and my scrubber is kept clean, a matter which they pointed out as a defect of the arrangements in some of the London gas-works.

I will now proceed to point out (although the same has been stated before) the conditions which I consider advisable, and which I adopt in all the works I erect.

1. Carry off the gas, ammoniacal liquor, and tar together in the one pipe, laid nearly horizontal, and commencing at as high a level as the hydraulic main will admit.

2. Cool the gas slowly and evenly. This I find best done by carrying a main against the wall of the retort-house, first inside, then outside, and finish-

ing in a water-condenser, rather than in pipes exposed to the fluctuating temperature of the atmosphere.

3. Before the condensing-pipe is allowed to descend, make provision for catching all the ammoniacal liquor and tar, and let it deposit itself in a cast-iron tank the top of which can very conveniently be at 1 to 2 feet below the level of the hydraulic main, and the bottom of it may be 4 or 5 feet above ground.

The object of this arrangement is that the process may be self-acting and require no manual labour.

A moment's reflection shows how very silly it is to allow all the tar and liquor to descend from the hydraulic main into a tank sunk in the ground, the whole of which has to be raised therefrom before it can be disposed of in any way; yet such is the general mode adopted in the construction of gas-works.

This reflection I am sure you will excuse, although it has nothing to do with the subject of this paper, for tar and liquor pumping is both an expensive and a nasty operation.

The tank being placed at the elevation I name, the liquor will run from it by its own gravity to the washer, which is placed on the outlet of the condenser.

The washer I employ breaks up the gas again and again, and it can be made to give whatever pressure is wanted by altering the level of the overflow.

From the washer the gas passes up through the scrubber, and this is supplied with pure water at the rate of 10 to 15 gallons to the ton of Newcastle coal carbonized. This scrubber has the following peculiarities, which I claim:—

Instead of a constant stream of water being run into it, I employ a douch at frequent intervals, which I consider more likely to wet the whole of the material in the scrubber than the same quantity of water run in constantly would, and the trays on which the material lies are of a peculiar construction that again compels a redistribution of the water, as it cannot run through unless where I have designed that it shall do.

The pure water run in at the top of this scrubber comes out at the bottom of 6 to 8 oz. strength, and I prefer to employ about 12 to 15 gallons per ton of coal being carbonized; and to determine this I have recently had a counter connected to the tilting apparatus, which records the number of gallons of water run in, and this is read off and compared with the quantity of coal used.

The liquor thus produced is, along with the other or ordinary ammoniacal liquor produced on the works, run through the washer.

Consequently, there passes through the washer a quantity of ammoniacal liquor equal to about 23 to 25 gallons per ton of coal, and the strength of it on leaving the washer is from 16 to 20 oz.—that is, it will require that quantity of sulphuric acid to neutralize it.

Means are provided for drawing off tar from the bottom of the washer. I am aware that there is an objection in the minds of some engineers to washers, because a washer gives pressure. I disregard this objection, unless where there is no exhauster. I am satisfied that the gas is brought effectually into contact with the water. I, besides, know that such contact deposits whatever tar there may still be in the gas, without which it would not be fit to enter a scrubber. The process, therefore, which I recommend is, wash with ammonia liquor first, and scrub with pure water last.

It has been recommended to wash or scrub with weak liquor, and without pure water. Such a method will not wholly remove the ammonia, as I proved in the experiment with 3-oz. liquor, the gas coming out of the scrubber equally impure as it went in; but when pure water was used, the purity of the gas was immensely increased.

This question of removing the ammonia from gas is one that I have been familiar with so long, that I feel it difficult to speak upon it in any way that assumes the slightest chance of what I say being successfully controverted, that I feel inclined to stop here and listen to what may be said to the contrary.

My connexion with the manufacture of gas commenced with Mr. Croll in 1847. This connexion lasted for ten years, during the whole of which time it was considered a *sine qua non* to purify gas from ammonia; and, from that time to the present moment, I have seen no reason to abandon a single conclusion come to, but to continue improving in the same direction, and during the fifteen years that I have been manufacturing gas, or building gas-works on my own account,

I have acted with that end in view. It is, therefore, often a matter of surprise to me to hear and to read what is said and written on this subject by both older and better educated men than myself, who still speak and write on the subject as if it was one yet in the stage of experiment and doubt. I will, therefore, conclude this paper by a few words to those whose works are not of sufficient magnitude to make the process a paying one.

I have several works in my own hands where the ammonia is worthless—either the quantity made is too small, or the works are situate out of the track of buyers of liquor. Nevertheless, *in every case* I extract the ammonia as a duty due to the gas consumer, as well as one that, indirectly, is beneficial to the company whom I represent.

Suppose the manufacture is under 10 millions feet of gas per annum, and the locality badly situate for the sale of liquor in such a case: I assume there is not an exhauster, then I use a scrubber, at such an elevation that the liquor from it can run into the ash-pans of the furnaces; for I contend that you have no right, legal or moral, to run it into the ground to poison wells, or into a drain to poison people, or into a stream to poison fish. I believe that there is no necessity for any of those malpractices, and I have no sympathy for any one who does it; it is either a symptom of ignorance, or laziness, to neglect to think out what, under any class of circumstances, may be done with this refuse.

The only difficulty that can arise is the fact of having to get rid of an additional 10 gallons of liquid per ton of coal used. This may be done under the furnaces, on top of the retort-beds with a connexion into the chimney, or by both.

There is, however, another mode, and one whch, if not profitable, may, at least, be done with little or no expense even in the smallest case—namely, to erect a good-sized purifier, and put yourselves in communication with some of the manufacturing chemists, who will send you a dry mixture of saw-dust and acid, which you can use in the purifier as you would lime, and when foul it will be received back by the chemist free of expense to the gas company.

There is also another way—and, in my opinion, the most legitimate way—but it is one that will require time to develope—namely, for each gas manager, in his own locality, to set about instructing those ignorant sons of the soil, called the aristocracy, and their creatures, the agricultural classes, into the benefit to be derived from ammonia applied to the soil.

This is very up-hill work, I grant—a species of eighth labour of Hercules, which will give enough to do to the most "muscular Christian." I have tried it, and with very indifferent success; nevertheless, I recommend a trial of it to you.

I know many of you may justly say, "I have enough to do in the multifarious duties of my position to increase them by increasing the volume of my ammoniacal liquor," but the result would be a lessening of duty; for, with the ammonia extracted, you would find the attendance out of doors, and the expense of repairs of meters and brass-work reduced by one-half or three-fourths, the indication of the meters more uniform, from fewer being stopped or changed, and, by consequence, less trouble and more satisfaction with the consumers.

You would, besides, find your purifiers less noxious to the men, and they would not require cleaning out so often. With so many inducements, if there are still any members of this institution who have not had time or opportunity to attend to the question, I am sure you will make a note to return home with the intention to set about it, seeing that it is no longer a moot question, but one that is backed up by every authority competent to advise on the subject.

Mr. Livesey (London) said Mr. Anderson had thrown down a challenge to the engineers of London, but he ought not to forget that his own reputation was made in London, after all. For himself, he was not quite prepared to admit that the London engineers were so much behind their brethren in this matter as Mr. Anderson endeavoured to make out; on the contrary, he believed they were fully able to hold their own against all comers. He was very much pleased with Mr. Anderson's paper, which furnished much useful information, but he felt bound to say that while the writer had been very free in commenting upon London engineers, he had not been generous enough to give them credit for improvements which they had carried out. Their friend, Mr. Mann (of the Blackfriars works), had certainly effected something valuable in the matter of removing ammonia. For years he had removed it entirely by that very beautiful

and ingenious contrivance of his—the brushwood revolving distributor. It was a misnomer to call it "Mann's Scrubber," for Mr. Mann had no claim to the use of coke, or coke in layers or tiers, because this had been already employed by Mr. Lowe. The only peculiarity to which Mr. Mann laid claim was the mode of distributing the water in the scrubber. The defect of this apparatus was that it required gearing to drive it. Mr. Mann obtained liquor of 20 ounces strength per ton, and removed the whole of his ammonia. He (Mr. Livesey) did the same, but he did it entirely without any gearing. Formerly he used coke, but had given that up, and now used thin bars of wood, and a common Barker's mill for distributing the water. Instead of a tumbling-box, such as Mr. Anderson employed, and which he had given up because of the noise it made in falling over, and because of the shaking it occasioned in the joints, he had contrived a little box or float, or a spindle, which actuated a valve. Mr. Anderson had quoted the report of the gas referees, but he ought to have stated that that report applied to only about three of the London companies—the Chartered, the Imperial, and the South Metropolitan. All the others were entirely independent of the referees. Their report also was directed more against the old works of the Chartered Company, where for want of space and proper conveniences the company had been unable to remove the whole of their ammonia. But those works were now done away with. As to the question of tar in the scrubber, he liked Mr. Anderson's plan very much. By his own arrangement, however, in which he added something to Mr. Anderson's mode, he had no tar whatever. Instead of taking gas from the water condenser to the exhauster he passed it through a series of very large pipes, so as to bring it to a state of rest. It there had the opportunity of depositing its tar and ammoniacal vapours which were already condensed. That plan had been in use two years, and during that period he had had no trouble at all with tar in the exhausters or scrubbers. The quantity of water he used was from 7 to 10 gallons per ton of coal, and the whole of the ammonia was removed. And here he would say that it was hardly fair to take the quantity of ammonia per ton of coal always, because there were differences in the qualities. He had been told by one manager in the Midland Counties that he obtained from 30 to 40 gallons of 10-oz. strength per ton, whereas he (Mr. Livesey) could not get more than from 20 to 25 gallons of that strength per ton. In the case of his own company, the ammonia in the gas did not average more than 1 grain per 100 feet. He used three scrubbers with liquor, and one with water to finish.

Mr. Anderson said Mr. Livesey was an excellent representative of the London gas engineers, and he might say that he knew Mr. Livesey when he hardly knew himself. Mr. Livesey had a father, not a very extraordinary circumstance, but one who had been of very great importance to him. Mr. Livesey, sen., was a man always open to conviction, and ready to welcome everything in the way of improvement? Whenever he met with any one who had invented something which promised to be useful, Mr. Livesey was ever willing to furnish him with the opportunity of developing it, and this often resulted in great benefit to the company of which he was the engineer. And so for many years experiments were made at the South Metropolitan works attended with considerable success. As for the London engineers generally being so exceedingly clever, he (Mr. Anderson) did not believe it. Most of those who were clever were men who had been imported from the provinces; indeed, he did not know what the metropolis would do but for the provincial and Scotch managers. Mr. G. Livesey, it was true, was a London engineer, but he was an extraordinary exception to the rule. It was true, as had been stated, that several of the London companies removed the whole of the ammonia from their gas, and he (Mr. Anderson) did not in his paper intend to throw discredit upon the whole of the companies—his remarks only applied to some. He only wished to call attention to those that were in default, and to let their managers know that he did not believe there was any necessity for building new works or conducting old works with 10 per cent. profits while retaining any ammonia in their gas. Certainly it was not necessary in building new works to have 40 grains of sulphur in every 100 feet of gas. The encomiums he had passed upon them were a piece of good nature, but the fact existed that those works had been badly constructed for the manufacture of good gas. He did not believe that any of the companies, Mr. Livesey's included, removed the whole of their ammonia by means of the scrubbers. They all used oxide of iron in the purification of their gas from sulphur after passing the scrubbers, and he found that if ammoniacal

liquor was passed through oxide of iron it was robbed of a large portion of its ammonia. He contemplated, at one time, purifying his liquor from sulphur before making it into salts as one way to prevent a nuisance. He succeeded thus in fixing the sulphur, but in so doing he found that he lost ammonia. There was no doubt that by passing gas containing ammonia through oxide of iron, a part of that ammonia was left behind. So much was this the case that manufacturing chemists were anxious to supply gas companies with oxide of iron free, provided they received the material back again after use, the reason being that they not only recovered the sulphur but a large quantity of ammonia from it. They took care to put into the oxide such substances as would fix the ammonia, and to those companies which did not take out the ammonia for their own use it was a beneficial arrangement, because the gas was thereby improved. He did not think the manufacturers would gain much from him, so far as ammonia was concerned, because he took it out of his gas by the double process of washing and scrubbing. The referees in their report stated, he believed, that Mr. Mann took out the last of the ammonia in the process of oxide of iron purification. With regard to the remarks made by Mr. Livesey about the tilting apparatus—of course, there were many ways of effecting the same object—he preferred it because it enabled him to have a counter attached for recording the quantity of water supplied. Mr. Livesey did not state what was the strength of the liquor he delivered to the manufacturers.

Mr. Livesey: It is 10-oz. strength on the average.

Mr. Anderson said he did better than that. Mr. Livesey used from 7 to 10 gallons of water per ton of coals. During the last year he (Mr. Anderson) had increased the quantity of water used by him to 13 gallons, and he found the liquor was still quite strong enough for the manufacture of sulphate of ammonia.

The President said, with reference to ammonia purification, they must not lose sight of the fact that some years ago the prevailing opinion was that it was not desirable to take out the whole of the ammonia from gas. It was considered that it combined with the sulphur compounds, and caused them to pass off in a less objectionable form. The present scrubbing arrangements appeared to be perfect for the removal of nearly the whole of the ammonia. As to what Mr. Anderson said with regard to washers, he might remark that washers had been very much used, and he had a great respect for them; but taking what Mr. Anderson stated, that the legitimate object of washers was to remove the tar, he could only remark that it appeared to him this might be done in a much better way. In gas-works, where there was proper condensing power, no portion of tar passed from the condenser to the scrubber. Mr. Anderson had given the meeting a good deal of ammonia, and he (the president) was sorry that a little acid had been added as well. It seemed a pity that he should make the remarks he had done respecting the referees, because, so far as his (the president's) knowledge of the referees went, they were intelligent men, always open to conviction. As to London engineers, all he could say was that he thought too much was expected from them. Almost all inventions were brought out by men in charge of medium-sized works. A man having large works on his hands had very little time for making experiments or for hypothetical reasoning. He thought, therefore, Mr. Anderson had been rather too hard upon their London friends.

Mr. F. W. Hartley (Westminster) read the following paper:—

ON COOKING BY GAS.

The persistence—the vitality, so to speak—of prejudice is manifested, probably, in respect to no other useful application more strongly than it is in respect to the employment of gas for cooking purposes. It is still very generally believed that the flavour of the gas permeates the food cooked by its aid, and that a further contamination arises from the absorption by the food of some extraordinarily poisonous compounds which are producable by burning gas alone, and not by any other combustible body. Hence it is that although the advantages of gas for cooking purposes have been proven facts for more than half a century, and although its use has been adopted for cooking in hospitals, many clubs, gentlemen's mansions, public institutions, and places of entertainment, not more, perhaps, than 1 or 2 per cent., at most, of the general body of gas consumers throughout the kingdom so employ it. This state of things is

certainly not creditable to the producers and vendors of gas whose business—and it may with propriety be said, *duty*—it is to urge the employment for every really useful and beneficial purpose of the article they produce and sell, not only on the ground of commercial interest (for the extended use of gas for cooking would, especially in summer time, help greatly to keep the mains profitably employed), but on the higher ground of moral obligation towards their customers, who would, in the majority of cases, be vastly benefited by the substitution of gas for fire cooking, both in respect to economy and comfort. The advantages would, of course, be at the maximum in summer time, when the days are bright, long, and warm; when, therefore, the distributing apparatus does the least work, and when there is little or no necessity for keeping fires burning. The writer has said that the present state of things in respect to gas cooking is not creditable to the makers and vendors of gas, and he believes he is perfectly justified in asserting this, notwithstanding that he is perfectly cognizant of the labours of the late Mr. Sharp, of Southampton, and of contemporaries with him, of whom Mr. Goddard, at Ipswich, is an example, and of a number of successors down to Mr. Magnus Ohren, whose little book is the most recent, and who is an ardent advocate for gas cooking, because the writer recognizes the broad fact that gas cooking is not yet popularized, and he perceives that the advocacy of the use of gas for cooking is left far too much in the hands of those who are merely interested in the production and sale of cooking-stoves. Believing that a discussion on this subject by this association will be alike advantageous to producers and users of gas, the writer has, at the invitation of the committee, been induced to prepare this paper; feeling satisfied that it will be kindly and considerately received, notwithstanding that the knowledge of the subject displayed may, and, indeed, must be, far below that of many of the members of this association.

The writer purposes to do no more than open up ground for discussion by a few remarks on the construction of gas cooking-stoves, such as may be used by ordinary consumers—the materials of which they should be made, the kind of burners most suitable, the objections of the public, and, in conclusion, suggest some few arguments which may possess a little originality, and, in addition to those in existence, assist in convincing the incredulous in respect to the advantages and healthfulness of gas cooking. The writer expects in one or two points to be in opposition to the views and opinions of some, and he wishes it to be distinctly understood that he puts his views forward in no spirit of dogmatism. Papers for an association like this should be definite in expression, and it is better for a writer to be wrong and explicit than doubtfully right, for the wrong, when explicitly stated, is sure to be corrected, while the doubtfully right might pass unchallenged because not noticed or not understood.

In respect to construction, leaving out of consideration such large stoves as are used in hospitals, clubs, &c., the writer is of opinion that the oldest and simplest forms of stoves are the best, those which are mere cupboards fitted with a series of gas-jets at the base, and with an outlet tube or funnel near to or upon the top, the stoves being provided with a series of moveable shelves, adjustable as to height, and provided with the means of suspending one or more joints. Reverberatory stoves, with which the vitiated air is discharged at the lower part, the writer does not think well of; they do not perform their work better than the others, if so well; the products of combustion are less easily disposed of, and they are not so convenient and manageable; while he regards those in which an inner chamber is heated by the circulation of gas products throughout a space between the inner chamber and a surrounding pocket as positively disadvantageous, inasmuch as more gas must be required to perform a certain quantity of work, and it is a grave question whether the heated and moist air of the gas flame, when brought into contact with the food, and especially so in respect to meat, does not tend to the better cooking of the same, and the preservation of the juices. Moreover, the brisk circulation through a stove or oven, such as the writer advocates, tends to prevent effluvia of one article of food flavouring another. A common defect in gas cooking stoves or ovens is to make the air openings—especially at the base—too large, so that too active a circulation is kept up, and more gas needs to be used in consequence. The air openings should be capable of adjustment to suit the necessities of consumption, which vary with the articles to be cooked. The rectangular stove is by far the most advantageous, as it is more roomy and more convenient in use; but the shelves should be always self-sustaining when drawn two-thirds out of the

oven, so that the two hands of the attendant may be free to remove dishes, &c. A very simple method of rendering the shelf so self-supporting was suggested by the writer to a friend, and put into practice some time since.

As regards the material of which a stove is to be constructed, the writer prefers for small and moderate-sized stoves *wrought-iron*, because the stoves are lighter, cheaper, and more quickly heated up than cast-iron ones, or stoves of porcelain or fire-clay. If the stoves are double-bodied, with an air-space between the inner and outer parts, after the fashion of stoves constructed some years ago by Mr. Geo. Garnett, when at Portsmouth, or covered with a jacket of wood, after the style of the admirable stoves constructed by Mr. Sharp, so much the better, but these additions render the stoves more expensive.

As regards the kind of burner to be used in a gas cooking-oven, the writer is in direct antagonism to the generally received notion that the Bunsen—that is, the burner in which the gas is mixed with air before combustion—is the best. It is a common mistake, although it may be one into which none of the members of this association have fallen, that gas burned from a Bunsen burner yields more heat than when burned from an ordinary burner. It does no such thing, although it is true that, under circumstances such as will be mentioned presently, more heat may be utilized when a Bunsen burner is employed, but this cannot be the case in an oven. In proof of this position, the writer may mention some experiments which he made in cooking. Two burners were made to fit the same oven, one burner being of ¾-tube, on Bunsen's principle, and the other a ⅜-tube, with simple jet-holes. Two joints of meat and other articles of food, of the same weight and character respectively, were cooked in turn by the aid of each burner, and it was found that the same quantity of gas, as measured by a test-meter, was used in each case. To confirm these results, a delicate thermometer was suspended in the oven, so that it could be observed from the outside, and it was found that, for equal consumption of gas, the temperature was raised through the same number of degrees in equal times, until, in each case, the thermometer indicated 410° Fahr., at which point it remained stationary.

Another notion which the writer is disposed to believe to be erroneous, although he is not prepared with demonstrative evidence in support of his belief, is that with the Bunsen burner a more complete combustion of the gas is effected than with the ordinary jet. The writer has noticed that the effluvia from gas burned apparently in a proper manner from a Bunsen is sometimes much more offensive than the effluvia from the same gas burned under ordinary conditions, and this has led him to doubt whether the Bunsen approximates in its effects to the rendering of a combustion relly perfect. This is a question, however, upon which the writer bases no argument. The great disadvantage of a Bunsen burner, in an oven especially, is that the range of temperature producible is so limited; you must have a great heat or none at all, for if the gas be turned low the flame flies back to the source of supply, no useful heat is evolved, and intolerable and suffocating fumes are given off, owing to the imperfect combustion of the gas. With the jet, fishtail, or bat's-wing, the gas may be burned at almost any rate of consumption; hence food may be kept simply hot, if desired, and the oven, if kept bright and clean, may even be made available as a drying or airing closet.

For boiling purposes the Bunsen burner is to be preferred, because the bottoms of the vessels can be kept clean, and there is no smoke given off. As far as economy in gas consumption is concerned, there is not much to choose between a Bunsen and a bat's-wing. Some experiments which the writer has made show that 16 cubic feet of gas would raise a measured quantity of water in an open pot from 52° Fahr. to 180°, when burned in a Bunsen upright burner with the flame in contact with the bottom of the pot, and that 16·4 cubic feet sufficed to raise the same quantity of water to the same temperature when the gas was burned from a bat's-wing with the tips of the flame just touching the bottom of the pot; the per centage in favour of the Bunsen being only ·025 per cent. With the bottom of the pot 2 inches above the top of the respective flames, the advantage was decidedly on the side of the bat's-wing burner.

The objections against cooking by the aid of gas are, as far as the writer's experience goes, something like the following:—

1. That gas is a very noxious compound, and when burned yields products different in character and more prejudicial to health than coal or coke fuel does.

2. That the gas and the products of its combustion are capable of flavouring and contaminating, and do flavour and contaminate, the food cooked by its aid.

3. That cooking by gas is quite as troublesome and not more economical, in any sense, than cooking by the aid of an ordinary fire.

Against these objections the writer would urge, as he has on many occasions urged—1. That gas is composed of precisely the same elements as coal—namely, hydrogen, carbon, sulphur, oxygen, and nitrogen; and these elements, when combined in the form of coal or in the form of gas, on combustion in air or in oxygen, yield exactly the same products—namely, water, carbonic acid, sulphurous acid, and nitrogen, with perhaps minute portions of nitric acid, which is producible when a mixture of hydrogen and nitrogen is burned in air or oxygen, so that gas and the products of its combustion can by no possibility contain anything more hurtful than coal or the products of its combustion. The argument may be carried much further than this, however. The only real impurity in coal and in gas is sulphur, which exists in coal as pyrites, and in gas, as delivered to the public, as sulphides of carbon. Now, the best Newcastle house coal contains about 1½ per cent. by weight of sulphur, and some of the cheaper coal very much more. One highly pyritic sample which the writer analyzed, contained as much as 7 per cent., so that it will be fair to assume that the average for house coals is not less than 1½ per cent. Admitting this to be the case, then, 1 pound of coal will contain 105 grains of sulphur, which in burning yields 200 grains of sulphurous acid. One pound of gas of the gravity of ·410 would measure 34·4 cubic feet, and assuming that the gas contained *three* times the quantity fixed by Act of Parliament a few years since (20 grains per 100 cubic feet) as the maximum for sulphur impurity, or 60 grains, then 34·4 cubic feet would contain 21·6 grains of sulphur, and yield only 43·2 grains of sulphurous acid. Of the other products of combustion—viz., water and carbonic acid, gas evolves more of the first, which is perfectly innoxious, and much less of the second; for while 87 per cent. of ordinary house coal consists of carbon, coal gas, according to Lewis Thompson, contains only 72·1 per cent. by weight. So that 1 lb. of coal contains 6090 grains of carbon, which, on burning, is capable of producing 22,330 grains of carbonic acid, while 1 lb. of gas contains 5047 grains of carbon, capable in burning of producing 18,507 grains of carbonic acid. This statement does not, however, represent the true relations of coal and gas; their respective heating powers must be taken into account. It is easily proved by Thompson's fuel test that 1 lb. of house coal will raise 967 parts of water through 8° Fahr. of temperature, and the multiplication of these numbers together gives 7736. In other words, it may be said that 1 lb. of coal will at best raise no more than 8000 lbs. of water through 1° Fahr.

Dr. Letheby, in agreement with the experiments of Mr. F. J. Evans, stated in the valuable lecture delivered to this association in 1866, that 1 lb. of ordinary coal gas will raise 21,060 lbs. of water through 1° Fahr. of temperature. So that, in round numbers, 13 cubic feet of gas will produce as much heat as 1 lb. of coal. In respect to sulphurous acid, the gas would produce only 16½ grains, as against 200 for coal; and of carbonic acid gas would produce 6830 grains, as against 22,330 grains. It may fairly be said that a single down draught would cause more of these gases to pass over a joint roasting in front of a fire than it would be exposed to during the whole time of cooking in a gas-oven, and that a chop or steak cooked over a coal or coke fire is exposed to vastly more of these gases, but no person ever appears to have suspected that the meat would be contaminated, or the eater thereof be poisoned; certain it is that medical history fails to record any such extraordinary and lamentable result. The actual fact remains to be pointed out in respect to these gases, which is that, although they are injurious to enhale, and even quickly destructive of life unless largely diluted with air, they are quite harmless in any action on food, and that one of them—carbonic acid—is a necessary ingredient in water, beer, aërated fluids and bread, and is actually beneficial when taken into the stomach.

In respect to the second objection, it may be easily shown that food under the influence of a high heat, and especially of a circulating heat, is really indisposed or incapable of absorbing gaseous fumes or vapours. All articles of food, especially those which are cooked by roasting or baking, contain coagulative matters, such, for instance, as albumen. Albumen coagulates at about 150° Fahr., so that a joint is no sooner exposed to a roasting heat, which is

from 300° to 400° Fahr., than its outer surface becomes coagulated and practically impenetrable by gases; in addition to which steam is generated within the viands, and this is projected with so much force that it effectually repels the entry of anything else. True, in a close oven having no air circulation, there is a sort of general flavour communicated to meat, but the writer believes the contamination, so to speak, is confined to the surface, and is due to the complete saturation of the expelled juices, and the adhesion of a small portion of their coagulative matters as they flow over the joints, which effect is much more likely to ensue in the comparatively dry atmosphere of a close oven than in a gas-heated one.

As regards the first part of the third objection, it is sufficient to say that with gas there is no time wasted in the making, and waiting for a fire to burn up, and the labour is nothing. The gas has only to be lighted and adjusted, the food put in the oven, and it may be so nicely timed, with very little experience, as to require no attention until it is done, and needs taking out. As to economy, Mr. Ohren's experiments, which are quite concordant with others made by the writer, show that the cost of cooking joints of equal weights is on the average $2\frac{37}{100}$ths pence with gas, and very nearly 4d. with coal, while the absolute waste or loss of weight is twice as much, at least, with fire cooking than with gas cooking. Even if the fire be utilized for boiling purposes, and gas be used for both roasting and boiling, the writer found that gas was by far the most economical in relation to the weight of the food cooked.

The writer's experience also leads him to the conclusion that in cooking vegetables, puddings, &c., it is far more economical, on most occasions, to effect the cooking by steam, than to employ the gas directly for boiling.

The writer may mention a useful hint of the late M. Soyer, the great cook, to preserve the juices in boiled meat and ensure its tenderness: "Dip it in boiling water for a few minutes and then immerse in cold water, and raise it to the boiling point, and simmer until cooked." Apply this idea in gas roasting; raise the gas high for a short time, and then adjust to the requisite consumption. In each case, coagulation of the surface is effected, and the juices are imprisoned, or, at all events, in roasting the surface is coagulated more promptly.

The writer thinks that the facts and reasonings which he has adduced certainly show that gas, as applied for cooking, is, in comparison with other fuel—

1. More healthful.
2. More certain.
3. Less troublesome.
4. Less expensive.
5. Less wasteful, by loss of weight.
6. Less costly, unless, indeed, the waste heat from a necessary fire be employed.

While, lastly, it certainly is—

7. Much cleaner.

Mr. Ohren (Sydenham) said he had paid some attention to gas cooking, and differed with the writer of the paper on one point. Mr. Hartley stated that gas-stoves made of plain sheet iron answered for all purposes of cooking, and that he saw no benefit in using porcelain plates. When these stoves were originally made, plain iron plates were always employed in their construction, and when he (Mr. Ohren) first commenced to use them he found there was a great nuisance from the smells which escaped in the course of cooking; this he ascertained arose from the grease—from the spurting of fat in the joints—getting on to the plates, where it became burnt; when porcelain plates were employed no such unpleasant smells occurred. The reason why he preferred an atmospheric to an ordinary burner in these stoves when common gas was used was that occasionally the cook would turn the gas on too high, and not only smoked the stove but also the joint, which gave it a very unpleasant flavour. This carelessness on the part of cooks no doubt gave rise to the idea that cooking by gas was injurious to the meat. With an atmospheric burner there was no smoke. It was true, as Mr. Hartley stated, that there was occasionally a very bad smell from the atmospheric burner, but that arose from the same cause—viz., that of allowing too much gas to pass through it. When an atmospheric burner was turned up too high there was not a proper combustion of gas; the portion unconsumed escaped, and of course there was a smell from it. On this account it was that he advocated the use

of a regulator in gas cooking-stoves to adjust the burners to the exact consumption required. If regulators were adopted there would be no complaints of smells or nuisance of any sort, nor would any pipe be required to carry off the burnt products. Gas engineers ought to pay very careful attention to the stoves they supply to consumers, and see that they were properly constructed and fitted up; if they did so, cooking by gas would be rapidly extended. It was wonderful how little knowledge there was amongst gas consumers as to the benefits to be derived from the use of gas for cooking. Gas-stoves had been known for a long time amongst professional men, and had been employed in some localities perhaps more than in others, but the general public seemed to know nothing about them. His experience was that whenever they were properly introduced by gas companies the consumers readily availed themselves of them. In connection with his own company he had turned his serious attention to the subject, and had sent out a large number of cooking and heating stoves, which had given great satisfaction to the consumers.

Mr. METHVEN (Bury St. Edmunds) said neither the writer of the paper nor Mr. Ohren had touched upon the great objections to gas cooking. According to his own experience these might be regarded as two-fold; first, the cost of the stove, and secondly, the cost of the gas. Mr. Ohren had certainly indicated one method of surmounting the first objection—viz., the letting out of gas-stoves on hire by gas companies at a moderate rate; but the second objection was unremoved. He usually found that if the person who had charge of the apparatus was not the person who paid for the gas, it was extravagantly used, so that it was found very expensive even to heat a large quantity of water by means of gas. He had known an instance in which that objection had been remedied by affixing to each gas-stove a separate meter, and letting the cook know that he or she was responsible for the excess of gas consumed. He regretted that Mr. Ohren had given utterance to so heterodox a sentiment that in any case there was no necessity for a flue to a gas-stove. He (Mr. Methven) believed it was always necessary, and that the absence of any arrangement of the kind had caused much annoyance and trouble to those who used the stove. The products of combustion must go somewhere, whether an air burner or an ordinary burner were employed; and he was sure it was a great mistake to recommend a gas-stove for cooking purposes without there were the means of placing it under a chimney, or a flue leading directly into a chimney.

Mr. GODDARD (Ipswich) said he had perhaps had as much to do with gas cooking as any gentleman in the room. He was induced to devote his attention to it chiefly with the view of getting a daily consumption of gas in the town, so as to make the mains profitable by day as well as by night. Accordingly he advised the company he represented to supply gas-stoves, and all kinds of gas apparatus to the consumers, both for heating and manufacturing, as well as for baths, at a moderate rental. The arrangement was carried into effect, and had answered exceedingly well for a long period of time. He believed he was the first to introduce porcelain tiles into the construction of cooking stoves, about 25 years ago, and he did it for this reason—that porcelain being a better non-conductor of heat than metal, he thought there would be an economy in this respect, and, as it was very cleanly, it would avoid the unpleasant smells which were created of grease upon the hot metal plates. The plan adopted at Ipswich was for the company to supply the fittings and apparatus, and to do the work of fitting up, charging the consumer 10 per cent. upon the cost price. The great difficulty which had always attended gas cooking was the imprudent use of the gas by the domestics. He once fitted up a gas-stove to cook for 300 people, but the consumption of gas was found to be so large that the proprietor of the establishment felt that he must abandon its use. He (Mr. Goddard) recommended him to have a meter attached to the apparatus itself, and to offer an inducement to the person who had the management of the stove to reduce the consumption to its minimum amount. The plan succeeded admirably; day by day the register of the meter was taken and an amazing economy was effected. When the proprietor imagined that he had reached the minimum consumpton, he made a very handsome offer to the cook that for all gas saved beyond that point he would give him an equivalent amount. The consequence was a still further and very considerable reduction in the consumption, because

the gas was not allowed to burn when there was nothing to be cooked. He (Mr. Goddard) believed the only real difficulty which gas managers had to contend with in extending the use of gas-cooking apparatus, was the want of care on the part of those who used it.

Mr. JONES (Dover) said there was one objection not yet touched upon by previous speakers—viz., the necessity of having additional pressure on during the day time, and the consequent additional leakage sustained by gas companies supplying cooking stoves.

Mr. WARNER (South Shields) said some years ago a similar experiment to that recently made by Mr. Ohren was attempted; a pamphlet was got up and circulated, gas cooking-stoves of a novel character were devised, and a dinner arranged, to which the mayor and some members of the corporation, with the representatives of the press, were invited. They all partook very heartily of the banquet and enjoyed it much, and, as might be supposed, pronounced a highly favourable verdict on the plan. The system was adopted, and he did not think there was any alteration made in that instance in the pressure for the purpose of cooking apparatus, but this result arose from their introduction —viz., that during the first quarter after the introduction of the stoves, a very large additional quantity of gas was consumed—some hundreds of thousands of feet. He believed that wherever the plan was introduced this would be found to be the case, and the company would have a large part of their apparatus now lying idle during the summer months profitably employed. This was a very useful subject to be introduced for discussion at the meetings of the association, and he hoped all the members would derive advantage from it.

Mr. IRONS (Gosport) said he believed that at Bath the committee did put on extra pressure for certain houses where cooking-stoves were in use. At Gosport, one of his customers had a stove of this kind, and was rather dissatisfied with the supply of gas he obtained for it. Being a shareholder of the company, however, he was induced to remedy his complaint by enlarging his fittings. When he (Mr. Irons) was engaged in the suburbs of London, there were 400 or 500 cooking and warming stoves used in his district in private houses, whitebait taverns, and for greenhouses. There being great objections to chimneys for outbuildings in the neighbourhood, ordinary greenhouse stoves could not be used, and gas was employed for heating purposes. The one great difficulty which gas companies had to deal with was, the necessity for extra day pressure. If a sufficient number of consumers could be got to use them, if there were not such a prejudice against gas companies, and if people could be induced to follow the advice of managers, in having efficient fittings, the ordinary day pressure would in most cases be enough.

Mr. ANDERSON (London) thought the members were under obligation to Mr. Hartley for bringing this subject before the meeting. It was a practical question in which all present were interested, and upon which very much of the success of their undertakings depended. Almost all the difficulties to which they were exposed in reference to gas cooking arose out of the ignorance of the public or the prejudice so commonly felt against the adoption of anything new. He quite agreed with Mr. Ohren that in some cases a gas-stove might be fixed without a chimney, but that must only be where the ventilation was good, otherwise the products of combustion would necessarily become a nuisance. It required discretion and judgment on the part of gas managers in deciding what should be done, and in providing artificial ventilation where the natural ventilation of the place was inadequate. The adoption of gas-cooking apparatus would be a gradual process, and they must not expect consumers to be converted to it all at once. As to the necessity for increased pressure, of course, if it was desirable to encourage the use of gas-stoves, this must be provided, and if this resulted in increased leakage, it would make managers look out more sharply to detect it. At a place in Ireland where the works were under his control he had been called upon to supply gas to a milk condensing factory for the purpose of soldering the cans in which the milk was stored. The apparatus employed was a hot plate with a groove in it, which was filled with solder, and a nice even heat was required in its use. In that town no day pressure was given, but as it seemed to him desirable to encourage this branch of industry he resolved to try what could be done. Pressure was put on, the main-valve to the town was closed, and during the whole of the day the gas was passed through a meter. His experience then was that

the leakage was very little indeed, and the supply was continued in a most satisfactory manner.

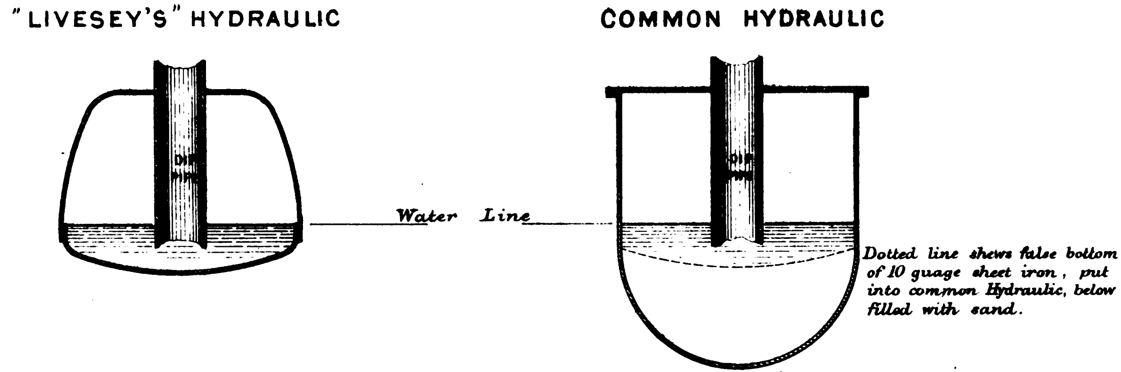
Mr. BROADHEAD (Grimsby) said he had some experience with this kind of apparatus in Leeds some years ago, and his experience was that on account of the smallness of the consumers fittings and the carelessness of servants in burning the gas when no cooking operations were in progress, that which ought to be an economical arrangement was a very expensive one.

Mr. OHREN said in all the experiments he had made with cooking apparatus in his district the pressure on the mains was only five-tenths. With respect to burners, it should be always borne in mind that there should be a sufficient number for the quantity of gas required, and that they should not be turned up too high. Instead of having a small ring of jets, and burning them at their maximum capacity, it was better to have a large ring and burn them at a moderate height. If this were carefully attended to, there was no more need for a chimney with a gas-stove than there was for a chimney over the burners in a room.

Mr. JOHNSON (London) said he had had great experience in gas consumption for cooking purposes. In the City of London district there were hundreds of these stoves in daily use, some which consumed 3000 or 4000 cubic feet of gas per day. He had always found the same objection which had been spoken of—viz., the expensiveness of the process owing to the carelessness of servants. A friend of his had just invented a small apparatus by which he made the joint of meat turn the gas on to the proper height. It acted directly by a lever on the cock which supplied the gas, and when the joint was taken away, the act of removing it turned the gas down to a small blue flame. By this means it was put beyond the control of the servant altogether. A similar arrangement made the removal of a saucepan turn down the gas beneath it until it was wanted again. This apparatus was also applicable to tailors heating apparatus and for soldering irons, and every description of burner used for heating purposes. If gas engineers would direct their attention to this arrangement, he thought they would be able to induce people to use gas much more generally than they had hitherto done.

Mr. HARTLEY, in reply, said that he was happy that the subject of gas-cooking excited so much interest, and that those gentlemen who differed from him on certain points had so frankly spoken. Mr. Methven stated that the principal reason why gas cooking-stoves were not more widely used was that gas cooking was costly, owing to the extravagance of servants, who would waste the gas. He (Mr. Hartley) had experienced something of this waste, but the fault was not in the gas—other fuel was also wasted by servants, and it certainly would be quite as reasonable to find fault with the coal merchant as with the gas-maker. Gas-makers could teach people how to use cooking apparatus, and then leave them to make the proper application of the fuel. In dealing with cooking in the paper, he (Mr. Hartley) had of course addressed himself only to the relative value of each agent when properly used. Gas-stoves were made of various materials, and opinions as to the advantages of each would differ. Porcelain plates were certainly clean, and possibly, as Mr. Goddard said, there was less radiation externally, but these plates could not be entirely disassociated from iron frames, and in spite of all care in fitting, there was a liability for the grease to get on to the iron, and then some unpleasant smell would be produced, although perhaps not to the same extent as with simple black iron stoves. He (Mr. Hartley) preferred tinned iron for the body; it stood well, was cleaner than untinned iron, and gave off much less of objectionable fumes when the grease came into contact with it. With respect to burners he adhered to the preference he had expressed for the ordinary jet or fishtail. Mr. Ohren said these gave rise to smoke, and that when governors were used with the atmospheric burners, there was no difficulty attending their employment. Well, governors could be used with the ordinary burners just as readily as with the atmospheric, and smoking thereby be prevented. In fact all gas-ovens should be supplied with gas through governors. In respect to day pressure and its increase, that was a matter for experience. In London and many large towns, no increase of day pressure is needed for cooking purposes, because the companies are obliged, under Act of Parliament, to keep up sufficient pressure in the day time, and no doubt a similar obligation will be imposed on most, if not all the gas companies in the kingdom, and it would then become a question of utilizing what is given. He (Mr. Hartley) begged

LIVESEY'S HYDRAULIC MAIN.



Scale $\frac{1}{16}$ = *1 Inch.*

Litho Whiteman & Bass, 236, Holborn, London.

in conclusion, to thank the president and the members for the courteous attention they had given to him.

Mr. G. Livesey read the following paper :—

THE HYDRAULIC MAIN.

The title of my paper is rather wide and indefinite, but as the interest by general acknowledgment attaches more to the discussion than the paper, and the subject being one on which so much can been said, I think in so wording the title that members cannot well be out of order in speaking on it. I shall make an opening for remarks that may be very valuable, though I intend confining myself strictly to a description of a difficulty and to a means of successfully preventing its occurrence.

The old-fashioned D-shaped main, with a bridge at every length to keep the seal at the proper level, in the event of any alteration of level in the whole length of main, seems to have been specially contrived to retain the thick tar and convert it into pitch, to be removed once a year or oftener by taking off the covers and digging it out after having with great labour broken it up with clinkering spuds and chisel bars.

The substance thus removed consisted of a mixture of pitch or very thick tar, and crystals of muriate of ammonia conglomerated into a very solid mass, and which filled the main nearly to the water level, with a small basin or cup as it were under each dip-pipe, just allowing the gas to pass—this cup being in fact formed by the passage of the gas, but instead of having a free passage the resistance in time became so great as to produce a tendency to frequent stoppage of the dip-pipes.

Various means have been tried to prevent or clear out this accumulation of thick tar, one being an enlargement of the hydraulic itself till, in one case that I have seen, each length would make a small Cornish boiler; then the elevation of the hydraulic from two to four or five feet above the brickwork with the object of removing it beyond the reach of heat—it being considered that the heat from the setting converted the tar into pitch. A stream of gas liquor has in some cases been caused to flow through the main, and for a long time I had a quantity of hot water from the steam-boiler put into the main once or twice a week; but this did very little permanent good. The making the main deeper and square at the bottom has been suggested, means for drawing off the tar from the bottom instead of the top have been devised and used with varying success, but by no plan, so far as I am aware, has the prevention of this accumulation been certainly and completely attained.

The causes of its production are twofold: first, the retention of the tar in the main; and second, the heat of the gas from the retort in passing through this comparatively stationary tar evaporating its volatile constituents; for *it is the hot gas and not the radiated heat from the setting that does the mischief.*

If, therefore, one of these causes could be removed, a good result would be obtained by reducing the temperature of the gas before it reaches the main (this has been done by Mr. Morton, of the London Company, by lengthening the ascension-pipes), or carrying away the tar immediately it is deposited, or by keeping it in motion, and not letting it be a sufficient time in contact with the hot gas to volatilize its lighter constituents. On thinking over this matter I asked myself—What is the use of that large space below the bottom of the dip-pipes? It is certainly not required to allow the gas to pass, for the gas does not extend 2 inches, if an inch, below the edge of the dip-pipe; consequently, the heavy tar sinking to the bottom is never disturbed. It then occurred to me to put a false bottom in two of the mains at the South Metropolitan works; this was done by means of a plate of 10-gauge sheet iron, dished to the extent of 2 inches, placed so that in the centre it was just 2 inches below the bottom of the dip; the area of the main above the bottom of dip was therefore not reduced; the space below the false bottom was filled up with sand. I considered that the false or shallow bottom, having a smooth surface, the tar would not be so likely to adhere; seeing that the bubbling through of the gas would always keep the centre disturbed, and thus produce a circulation from the centre to the sides. The result exceeded my expectations, for after a winter's working I had the covers taken off the hydraulic in several places when the whole of the beds had been some time out of use, and the tar

had had a chance of becoming cold and stiff; I found it in a perfectly fluid state.

The next summer I had nearly the whole of the hydraulic mains fitted in this way; in one division of the retort-house a new main, of the section shown, was put up in place of the old sort, and but one length of main, having a 2-inch perforated pipe laid along the bottom, through which water from the steam-boiler could be sent, was left without alteration. I had therefore last winter an opportunity of thoroughly testing the plan, and with again the same result, the tar perfectly fluid, no pitch or thick tar, and no crystals or ammonia, and better still in the whole of the mains with the shallow bottoms I might almost say *there was not a stopped dip-pipe all the winter;* and *stopped ascension-pipes were of much more rare occurrence;* in fact, though I often made the inquiry of the foremen and other men, I always got the reply that *they had no trouble with them.* In the length of main fitted with the *water-pipes* the dips *stopped as usual.*

The form of main (see section) I now use is much lighter, because smaller than those used formerly, though the area for water is the same; there is, therefore, a *saving in first cost. Another considerable saving* results from the gas passing the seal with much greater freedom, the *cost of cleaning* dip-pipes is saved, and consequently the retorts work constantly, and the very dirty and expensive job of cleaning out the main periodically is avoided. I think the thing was worth a patent, but had I protected it, I should not have appeared before you to describe my invention. It is, after all, a small matter; but if it be an improvement, and one that will relieve gas managers to some extent of one of their anxieties or annoyances (and they have their share of these now-a-days), they are very welcome to its use; and if the idea is really new, and not, as is quite possible, been tried before, let me ask you to speak of it as the "Livesey Hydraulic."

Mr. BARRATT (Accrington) asked what was the height of the hydraulic from he top of the bed.

Mr. LIVESEY said, 18 inches.

Mr. BARRATT wished also to know the height of each pipe from the top of the retort.

Mr. LIVESEY said, about 10 feet. The dip-pipe extended about 2 feet above the top of the hydraulic.

Mr. OHREN asked whether Mr. Livesey found 2 inches dip in the hydraulic was sufficient, and whether, if he had made the dip-pipe longer and brought it nearer to the bottom, he would not have had an advantage by obtaining a greater gas-way from the main?

Mr. ANDERSON said he did not gather from Mr. Livesey what was the chief object in making the alteration, unless it was the saving of the necessity for cleaning out the hydraulic main and the avoidance of stopped pipes. But for himself, he did not know that it was a necessary condition of making gas that they should clean out the hydraulic, or that they should have stopped pipes. The cause of the latter was that the heats employed were too great, so that the naphtha, which had been in the gas in a state of vapour, was volatilized out of it, and that the tar in the gas was converted into pitch in traversing the pipe. It did not matter how large the pipes were, for if the heats were very great, a stoppage must be the result. He had tried pipes of 8 inches diameter, and all the difference was that they did not stop up so quickly as those of 4 and 5 inches diameter. With reference to the suggestion of Mr. Livesey, there was one advantage in it, that it was not necessary to have so large a hydraulic, and therefore it was more economical. But he thought that with the dip-pipe so near the bottom of the main there would not be so free a flow for the gas. By the mode suggested the tar would be caused to flow away faster, and would not be allowed to accumulate.

Mr. MILES (Deane) thought Mr. Livesey was recommending them to do something they were advised last year not to do. At the meeting in Dublin Mr. Somerville recommended managers to have square, or rather, rectangular hydraulics, and that recommendation was received with great favour. Another thing they had been taught was to have as much room in their apparatus as possible. But according to Mr. Livesey's suggestion they would be contracting it. Why not go back to the 15-inch circular hydraulic? Or why should not Mr. Livesey carry his dip-pipe 4 or 5 inches lower instead

of making his hydraulic shallower? He (Mr. Miles) could not see the advantage to arise from the alteration in any way.

Mr. IRONS (Gosport) said the subject of the hydraulic main was a very important one, and he should like to ask a question of Mr. Livesey. In his paper Mr. Livesey alluded to the stoppage of the dip-pipes, but said nothing about the ascension-pipes. Now he (Mr. Irons) quite agreed with Mr. Anderson that the stoppage of the latter arose from the heat from the retort. If a manager had leaky retorts and was using an exhauster, he would find that these were the pipes to stop soonest. What he wanted to ask Mr. Livesey was, whether, presuming an exhauster was used, he ever had a back action? also, if the space between the bottom of the dip-pipe and the false bottom of the hydraulic was equivalent to the area of the dip-pipe, or whether he had to use more exhausting power to keep the same vacuum in the ascension-pipes?

Mr. MEAD (Reigate) said he was afraid some of those who had spoken had not grasped the theory of Mr. Livesey's invention. With reference to the distance of the bottom of the dip-pipe from the bottom of the hydraulic, that must depend upon the size of the latter. If the dip was a 4-inch pipe he must have 1 inch from the bottom of the hydraulic to allow the whole of the gas to pass. The advantage of the proposed plan was that instead of allowing the tar to remain idle in the dip and the main by reducing the depth, he caused the whole of the tar to flow away. So far he thought this was an improvement.

Mr. SIMPSON (Rugby) asked whether Mr. Livesey had ever tried taking away the tar from the bottom of the hydraulic main. His experience was that by taking the thick tar as deposited from the bottom of the main the whole difficulty was removed.

Mr. LIVESEY said he had been pleased with the observations offered upon his paper, and would briefly reply to the suggestions which had been made. As to the question about the longer dip—had he lengthened the dip it would have reduced the available area of water for the seal. In old D-shaped hydraulics, it was simply half a circle, starting from the level of the bottom of the dip, and if he had brought the dip down to within two inches of the bottom, there would have been but a very small space of water to seal it, whereas by putting a false bottom at the level which he adopted, he retained the whole of the water level for the seal. As to the gas-way—he thought he had certainly left enough for any number of retorts. With reference to stopped ascension-pipes, Mr. Anderson was quite right in what he said, but he (Mr. Livesey) thought he could throw a little light upon the subject. Probably every one present remembered the instance of a large company who erected their works with one ascension-pipe only to their retorts, the result being a complete failure. He had himself tried a little experiment to determine the matter. He adopted one downward pipe from one end of the retorts, and had the ordinary ascension-pipe from the other. On some occasions he passed the gas one way, on others the reverse way, and he found in both cases that the pipes became in eighteen hours completely stopped up with hard stuff like iron. He came therefore to the conclusion that it was the heat of the gas which caused the carbonization of the tar, and converted it into this solid coke. When gas was taken from the two ends of through retorts, half the gas went up one ascension-pipe, and half up the other, and each half of the gas travelled one quarter of the length of the retort, but if the gas was taken from one end, one half travelled over three-quarters of the length of the retort, and the other half over a quarter only. In this way the heat imparted to the gas in passing over the whole of the hot coke, caused so much heat in the ascension-pipe as to carbonize the heavy tar. Supposing that in an old main there was a collection of this thick tar which caused considerable resistance to the passage of the gas, if the other end was tolerably clear, the whole of the gas would pass in that direction, and in the course of a day that end also would be stopped up. But by taking care that the tar was always perfectly fluid, there was an equally free passage on each side. As to the question about making the hydraulic smaller, he thought he had already answered that, and he need only add that the object of making the bottom square and deeper was, that there should be more room for the pitch to accumulate, and no need to clean it out frequently. But if the accumulation could be prevented altogether, it was far better than having to remove it. His

dips were 4-inch pipes, and the reason why he had the bottom 2 inches below instead of 1 was, that he thought the bubbling of the gas through would keep the tar in motion, and that if he had the bottom nearly flat and only 1 inch below, there would be no tendency to slide down towards the centre, whereas with an incline of 2 inches, it would flow down. He started with his curve at a level with the dip-pipe. With respect to Mr. Simpson's inquiry, he might remark that he had not tried the experiment of taking the tar away from the bottom of the hydraulic. Some of his friends had done so, at times succeeding, and at others failing. The plan which he had adopted did succeed so far, and it was only a few days previously that he found on removing the cover from a main with a false bottom, that he could stir the tar about with a stick like the ordinary tar about the place.

At the Afternoon Sitting, Mr. R. Fish (Hornsey) read the following paper:—

ON THE COMPARATIVE COST OF PURIFYING GAS BY LIME AND OXIDE OF IRON.

Mr. President and Gentlemen,—Having been invited to read a paper before you, I beg to draw your attention to a subject which, so far as I know, has never been discussed at these meetings—I mean the comparative cost and advantages of purifying by lime and by oxide of iron, together with the revivification of the latter.

And, although I cannot boast of having charge of very large works, which might lend an air of authority to what I am about to state, I may say with confidence that I have given considerable attention to the subject, and this it is that makes me less reluctant to address you than I otherwise should be.

With reference to lime, I think there is no one but will admit its worth as regards its purifying merits, but the great inconvenience felt by the accumulation of it, and therefore its liability to create a nuisance, together with an increase of cost, have caused the use of oxide of iron to become more general of late years, for it must be borne in mind that what with our Government inspectors, our local boards, and a great number of others, whom we might well term nuisances, it is manifestly to our advantage to reduce any additional nuisance to a minimum, especially as the abatement of it tends to the comfort and convenience of all concerned.

As regards oxide of iron, it is well known that in its fresh state it freely absorbs the sulphuretted hydrogen of foul gas, thus forming the black sulphide of iron; this, when exposed to the atmosphere, deposits its sulphur, and by the absorption of oxygen becomes converted again into oxide of iron. The sulphur which it had before taken in as sulphuretted hydrogen is thus set free among the particles of the oxide, which, by a succession of foulings and revivifications, become so charged and clogged with inert sulphur that the air loses the power to restore it. Even then the spent oxide has its value, and my firm conviction is that when the sulphur compounds become more widely known competition for the spent material will further increase its value.

I cannot argue that oxide of iron has no drawbacks, although it is unquestionably cheaper than lime, but in the course of revivification it gives off unpleasant vapours, and the cost of labour for its frequent removal from the purifiers is very considerable. It is to this important matter (namely, the cost of labour in the revivification of oxide, and the reduction of what in some situations might be considered a nuisance arising therefrom) that I am more especially anxious to draw your attention presently.

As to the saving effected by the use of oxide (with a small portion of lime to take up the carbonic acid), I find after taking the labour connected with oxide into consideration, there is from 40 to 50 per cent. in favour of oxide, but few agree as to the exact cost, this varying according to the price of both materials, the consumption of gas, the adaptation of the oxide and lime houses in proximity to the purifiers, and the means adopted for taking out the oxide and refilling the purifiers.

In order that I may explain the matter more clearly, I will give you the precise cost of purification and labour by the two processes which have been used in the works over which I have the charge.

FIS

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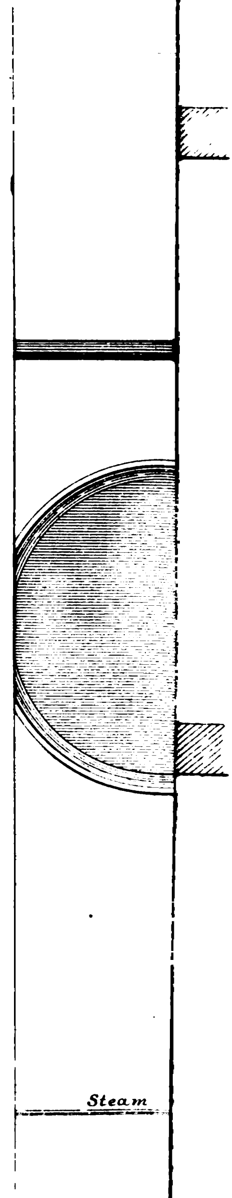


Litho Whiteman & Bass

In the year 1868 our consumption was 10,191,000 cubic feet of gas, and we used for purification—

62 tons of lime, at 16s. 3d.	£50	7	6
Labour, cleaning and refilling purifiers	5	13	3
	£56	0	9

Average cost per 1000 cubic feet, 1½d. and ½.

This sum, I felt, was too much, and should be reduced; and having experienced, as I have already stated, the nuisance arising from foul lime, and being almost prohibited from removing it from the works, I saw the necessity of resorting to the use of oxide of iron and lime, the result of which was as follows:—

In 1869, 1870, and 1871, our consumption was 53,256,000 cubic feet of gas, for the purification of which we used—

500 bushels of Hill's oxide, at 1s. 9d.	£43	15	0
53 tons of lime, at 16s. 3d.	43	1	3
Labour, cleaning out purifiers	125	16	4
	£212	12	7
Deduct value of spent oxide	45	0	0
	£167	12	7

Average cost, ¾d. per 1000 cubic feet.

The method which I am about to explain has been in use at the Hornsey Gas-Works for more than five months, and is one that I have thought of sufficient importance to obtain "provisional protection" for. The plan adopted is this—I provide the purifiers with an inlet and outlet, independent of the inlet and outlet for gas, and each inlet is furnished with a valve, to which is attached a short, open, and somewhat funnel-shaped pipe. Within the mouth of this pipe a nozzle (in connexion with a pipe from an ordinary steam boiler) is inserted, the use of the apparatus being as follows:—

When the purifier requires changing, the gas-ways are, of course, closed, and the air-ways opened; a tap is then turned, and steam passes through the nozzle into the purifier. The effect of this is to cause a rapid current of air to pass through the purifier, and permeate the purifying material, then to pass into the outlet, where it is thoroughly diluted with steam, after which it rapidly ascends and mingles with the upper air. Thus by the employment of steam in the manner described there is not only a sufficient current of air induced for a complete revivification of the oxide, but the use of it keeps the purifying material from getting unduly heated, and produces that degree of dampness most suitable for this purifying agent.

The cost of alteration for my four purifiers (as per plan) has been £24, but the price would somewhat vary, according to the distance to the ventilating shaft.

The cost of cleaning out and refilling purifiers, together with the time taken up in preparation for the same, amounts to 10s. each purifier. I have taken out the oxide from the purifier after five complete revivifications, and after more than 2 million cubic feet of gas had passed through, and found the material in good order; indeed, I am of opinion it would have answered three times as long without causing any additional back pressure.

Therefore, assuming that the plan which I now adopt had been in use for the last three years, I should have saved no less a sum than £106; this would make the average a farthing, and supposing a purifier would pass 200,000 or 250,000 cubic feet of gas before requiring cleaning, by the use of the method I propose, there would be a saving of labour to the amount of £2 per million cubic feet in one case, and £2 10s. in the other.

I therefore think you will readily see that, by adopting the process I have suggested, the trifling outlay would soon be repaid, while the general benefits to be derived are both permanent and substantial.

In conclusion, gentlemen, I would simply observe that I had much wished to have gone into other details connected with this matter, but have condensed it as much as possible in order that I may not trespass too much on your valuable time.

Mr. HODGSON JONES (London) asked the writer whether, since the use of steam, he had been less troubled with naphthaline than previously. His reason for asking the question was that at one of the Lyons stations, a process of the revivification of the oxide by means of steam was employed, and the result was entirely to do away with naphthaline in the purifiers.

Mr. BARRATT asked Mr. Fish the cost to him of lime per ton.

Mr. BROADHEAD (Great Grimsby) said he used lime entirely at his works, and he found that, for the year ending Dec. 31, 1871, they used 254 tons of lime, a at cost of £124 12s., to which must be added for labour £84 16s., making together, £209 8s. Deducting (£40 0s. 6d.) the value of impure lime sold, the net cost of purifying 48,416,000 cubic feet of gas was therefore £169 7s. 6d., being 0·839d., or a little under 1d. per 1000 cubic feet.

Mr. CRAVEN (Batley) asked how long it took to revive the oxide in the purifiers by the method suggested. The figures which he had written out as to the cost of purification by lime agreed very nearly with those of Mr. Fish —viz., 1·15d., as against 1¼d. for material and labour. Since he had adopted the combined materials, iron and lime, the cost had been reduced to ¾d. per 1000 cubic feet of gas.

Mr. SYMS (Rochester) said the cost of purification at his works by means of lime only was in 1870 about 1s. for 30,000 cubic feet of gas.

Mr. KELSALL (Ashton-under-Lyne) said the cost would of course depend largely upon the value of lime in different districts. At his works it was found that, exclusive of the sum received for spent lime, which was comparatively small (only 6d. per ton), the cost, on the average of the year for material and labour was only ·57d. He doubted whether any one, whether using lime alone or the combined process, could reduce the cost of purification below that.

Mr. BARRATT said his make of gas last year was 48,500,000 cubic feet. He purified with lime alone, and the cost, including material and labour, was only £12 17s. 6d., which was below ·50d. per 1000.

Mr. G. ANDERSON said he had tried oxide of iron and lime for purification, and would like to make a remark or two on the paper just read. In the first place, oxide of iron would not purify gas as lime would. It only removed one impurity, the sulphuretted hydrogen, with a small portion of ammonia, which those who understood their own interests did not wish to have removed. On the other hand, lime removed both sulphuretted hydrogen and carbonic acid, the two greatest impurities in coal gas, and those which had made the gas managers profession the most difficult. It was very well known that oxide of iron had only been adopted for purification because of the nuisance occasioned by dry-lime purifiers. That nuisance arose from the anxiety to make good gas without knowing sufficient of the operation. If the lime was removed from dry-lime purifiers the moment it gave a black test by acetate of lead paper, a great mistake was committed, because it would continue to do good in the purification of gas for a long time after it ceased to attract the whole of the sulphuretted hydrogen. By the use of lime in a proper manner, having the purifiers large, and allowing the gas to pass through in a very quiescent state, they would not only get rid of the impurities named, but also the bisulphide of carbon, which at the present moment was perplexing the gas interest of London. Formerly, there were two gas-works in operation in the town of Dover, and the purifying power being largely in excess of the actual requirements, they were enabled to carry on the process as he indicated, the result being that they had sometimes purified to the extent of 30,000 cubic feet of gas per bushel of lime. As to the relative cost of the two materials, every one knew that purification by oxide was far more expensive. Taking the same cubical contents of oxide and lime, the latter would last two or three times longer than the former. Managers ought, therefore, to pause before they abandoned the use of lime in order to adapt themselves to the mushroom notions of the day. He had an opinion that gas purified by oxide of iron did not possess so high an illuminating power as the same gas would have if purified by lime, and he believed it would be found that there was more naphthaline formed in the course of oxide purification. As to the principle of revivification suggested by Mr. Fish, he would only say that if he could succeed in doing it in the purifiers without the necessity for removal, it would be a great economy of labour, and he would accomplish that which had been before attempted, but hitherto unsuccessfully, in London.

Mr. HUNTER (Rochdale) said he agreed more with Dr. Odling than with any of the speakers on the present occasion—viz., that they ought to use lime in the first box until it became sulphide of calcium, and to use it still as sulphide of calcium until it became carbonate of lime, allowing the sulphuretted hydrogen to pass to the next box, and employing oxide of iron in the last box. By the adoption of the oxide of iron process in combination with lime at Rochdale, a saving had been effected of something like £300 or £400 per annum. They had the oxide material brought to them and taken away, and were allowed the use of it without any cost whatever. With regard to Mr. Kelsall's remark about the cost of lime being only ·50d. per 1000 cubic feet, he did not think he could compare favourably with him, but there were other circumstances than locality which might influence the matter. In some cases there might be small purifiers, in others an excess of purifying surface.

Mr. PARLBY (Aylesbury) remarked that the cost of purifying by oxide must of course depend greatly upon the price put upon that commodity. Since using it he had found the price to vary considerably; some firms supplied it as low as 15s., others as high as £3 per ton, and this too not altogether because of the difference of quality. The method of purification would likewise affect the cost; some works used more lime than oxide, others more oxide than lime to purify the same quantity of gas, and where this was the case there was sure to be some disparity as to the result. In his works he used oxide and lime in the usual manner; but, taking the report of the referees and the observations of Dr. Odling, it appeared to him that there was a great deal to be done before the process of purification was perfect. The cost of purification by lime alone at his works was ¾d. per 1000 cubic feet; by the use of oxide and lime combined the cost was reduced to ½d., and he hoped still further to economize the expense.

Mr. HARDICK (Salisbury) said he had frequently visited the Bath works, where a somewhat similar process of revivification of the oxide was adopted by the manager, and from his own knowledge the oxide material in the purifiers had not been changed for six months.

Mr. WOOD (Hastings) said he had manufactured his own oxide for the last four or five years very successfully by dissolving up the old iron of the works with sulphuric acid, using the sulphate of iron in a liquid form with sawdust, which made a very active oxide. It had never cost him more than 8½d., and seldom more than 7d. per bushel.

Mr. WARNER called attention to the importance of keeping the purifying apparatus on longer; it was better for the gas itself, and was much more economical.

Mr. ELDRIDGE (Richmond) said he had recently visited Mr. Fish's works, and was much pleased with what he saw there of the practical application of his system. It was a generally recognized fact that the great drawback to the use of the oxide process was the expense of emptying and charging the purifiers by the revivifying of the spent material. When at Mr. Fish's works he saw the gas tested in a dirty purifier, and found it was very foul, and on the cover of the purifier being removed the oxide was perfectly black. Mr. Fish then applied his method of revivification, and on visiting the purifier four hours afterwards he ascertained that it was most successful, and that there had been a thorough revivifyng of the material. He felt that this was a matter worth the consideration of every gas manager, and that they were all under great obligations to Mr. Fish for his simple and most effective contrivance. It appeared to him that the oxide was as clean as when the purifier was first charged.

Mr. FISH said he would endeavour to reply to the questions in the order in which they had been put to him. Mr. Hodgson Jones asked whether there had been any diminution in the amount of naphthaline since the adoption of this process. He was happy to assure that gentleman and the meeting generally that in the last six years, during which he had represented the Hornsey Gas Company, he had never seen a teacupful of naphthaline in any of the vessels. As to the cost of lime—at Hornsey it was very dear, averaging 16s. 3d. per ton delivered on the works. With reference to the time taken up in revivifying the oxide, Mr. Eldridge had kindly spoken on that point, and he could also bear out his statements that those purifiers, 12 feet square, and containing 10 tons of oxide, were effectually revivified in 4 hours. The operation might have been completed in 3½ hours. In one of his purifiers gas

was turned in on the 1st of Feb. last, and up to the 1st of June inst. 8,882,000 feet of gas had passed through it without the purifying material being once removed.

The PRESIDENT thought there was one matter in his paper which Mr. Fish had overlooked, and which, as it came under his (the President's) cognisance officially, he would state—viz., that the amount of sulphur compounds in the gas at Hornsey amounted to no more than 15 grains per 100 cubic feet. With reference to the process under discussion, he had seen it in operation, and had a very high opinion of its efficiency. It certainly effected a great saving of labour, and revived the oxide in much less time than it could be done by any method with which he was acquainted. In speaking of the various methods of purification adopted by London engineers, he (the President) must express his deep regret that Mr. Anderson had indulged so much in personal remarks on the present occasion, because those remarks were quite uncalled for, and their use only tended to throw discredit upon the association before which they were uttered. He would only add, that he earnestly hoped they would be avoided in the future. It was a very painful matter to be compelled to speak thus, but his position as president forbade that he should allow the remarks referred to to pass unchallenged.

Mr. R. H. JONES (Dover) read the following paper :—

ON THE INCREASED PRICE OF COAL AS AFFECTING GAS COMPANIES.

In introducing this subject to the members of the British Association of Gas Managers for their consideration, it is not necessary to write much, because the increased cost of coals, and the difficulty of procuring them at the present time, is a subject so materially affecting the financial position of all gas enterprise, that it must force itself on the attention of the shareholders at their meetings, when the Midsummer balance-sheets are presented to them, and it is therefore a matter which cannot fail to interest the members of this association, whose experience and opinions will, I am sure, be freely given, and may, I hope, point out some course of action to comfort and guide our directors in the present crisis.

That gas coals have materially advanced in price, and that they are most difficult to procure, must be a truism to all present at this meeting. While I write this (May 24) I have vessels which have been waiting in the Tyne upwards of five weeks, and are not yet loaded.

A few weeks ago a conference of the representatives of the gas companies south of London was held, when it was generally understood that the then increased cost of coals was equivalent to an increased cost of gas of sixpence per 1000 cubic feet. This calculation was based on the assumption that coal had increased in price 4s. to 4s. 6d. per ton, and that from every ton of coal carbonized 8000 feet of gas were sold. At the present moment the rise in the cost of coals is nearer 8s. per ton than 4s., and the question for consideration is how, with the raw material (coal) so much advanced in cost, is it possible to continue to supply the manufactured article (gas) without a corresponding advance in selling price. This question was somewhat cursorily discussed at the meeting I have referred to, and opinions were ventured that the April price of coal would not be maintained—that it was only a temporary rise in the market, which would soon right itself. I ask you, is that your opinion?

I expected to have seen that the shareholders of the London companies would have more seriously alluded to the price of coal at their meetings this spring; but the shoe had not then pinched, and former contracts at old prices were still unfulfilled.

In considering how far gas companies will be affected by the increased price of coal, the value of residual products must not be lost sight of. Has coke risen in price or is it likely to rise? In some places where the consumption of gas is small, it has risen to an extent equivalent to from a penny to threepence per 1000 cubic feet of gas.

Has tar improved in value? Yes, in the London district, in the immediate vicinity of tar distilleries, prices have improved to the extent of about a penny per 1000 cubic feet of gas; but do gas companies generally participate in this rise in the value of tar?

Has ammoniacal liquor risen in value? Yes, because sulphate of ammonia is

worth now more than it was in the spring of 1871, to the extent of about eightpence per ton of coals, or a penny per 1000 cubic feet of gas.

The large gas companies who have a market close at hand for their tar and liquor, will have the increase in the cost of their coals relieved to the extent of some eighteen pence per ton in the enhanced value of tar and sulphate of ammonia, a relief which will not much affect country works, especially those which are not in the immediate neighbourhood of a market for the sale of their tar and liquor.

It occurs to me, that those companies that have no reserve-fund, and are selling below their maximum parliamentary price, should not hesitate to charge their consumers an increase proportionate to the rise in the *net* cost of coal.

It would be well for those companies who are prohibited by Act of Parliament from raising the price of gas, to unite in an application to Parliament for relief, and this, I would venture to suggest, might be done by parliamentary authority being given to the Board of Trade to sanction, after due inquiry and investigation, an increased price proportionate to, and when and so often and so long as the cost of coal is in excess of an average price.

There is another class of gas-works to whom, I fear, no relief can be given. I refer to those small concerns where the consumption of gas is so limited that the price heretofore charged has come into pretty close competition with other modes of artificial lighting; to increase the price of gas in those districts would be almost suicidal, as the consumers would soon resort to the cheapest light, and all the time the coal market remains in its present condition. I fear the proprietors of those works must content themselves with a dividend "looming in the future."

Mr. FRASER (Inverkeithing) said, as a large coal owner, he might perhaps be allowed to make a few remarks upon the state of the coal trade in Scotland. In the months of March and April last year the coal owners in that country had very large stocks in hand. He himself had a stock of about 40,000 tons. At the present moment he believed no colliery owner had a fortnight's stock on hand. Last year the price was 5s. 10d. per ton, now it it was 11s. 6d. f.o.b., with a suspicion of a further rise. Two years ago Lochgelly cannel was worth only 9s. 6d., this year it was worth 17s. 6d., and they could not supply the demand. All the cannel coals in Fifeshire were in the same position. Some people might think that the coal masters were pocketing the difference in price as profit, but he would mention as a fact that he now paid for wages and expenses of working coals more money than last year he obtained for the coal itself, leaving out all account of royalties and the expenses for wood and other materials, which came to about 1s. per ton more. He suspected that gentlemen connected with gas-works would have to fall back upon some other material—the oil from shales for instance. The bituminous shales in Scotland were now selling very cheap, and he thought the able engineers of gas companies might, when necessity required, turn attention to these as a means of increasing the illuminating power of their gas.

Mr. J. G. LIVESAY (Ventnor) thought there should be a combined action on the part of gas companies to raise the price of coke, which was a matter not limited by Act of Parliament.

Mr. BROADHEAD said his company had been compelled to raise the price of gas in consequence of the increased cost of coal, and he agreed with Mr. Livesey that the price of coke would have to be increased.

Mr. WOOD (Hastings) said he had lately been instrumental in calling together the managers of gas-works in the south-eastern district of England, to consult on this subject, and it was admitted that it was impossible to avoid a rise in the price of gas before long. In many of the places represented, the increase had already taken place. The increased cost of coal affected gas companies in a variety of ways. Some companies had a good reserve-fund to fall back upon, and they would wisely wait to see how things would go on. Other companies who had been sailing close to the wind, now found that they were obliged to run before it. Some had greater facilities than others for getting in coals; with others the value of residual products was greater. At Hastings there was great difficulty in obtaining coals, there being no landing-place for the purpose; freights were also very high, and last winter, when the company first felt the effect of the increased cost of coal,

the price of coke was lower than usual, and they had a larger stock on hand than ordinary. This was to be accounted for by the fact that the consumption of coke depended upon a different condition of things to that of gas. The consumption of gas depended upon the weather; in dark, heavy weather it was necessarily increased. The consumption of coke depended upon the temperature—whether warm or cold. Last winter the weather was dark and heavy, but it was not very cold; the consequence was that, as in Hastings coke was mostly sold for domestic purposes, its sale went off very badly. He thought the general rise in the cost of coal throughout England must end in a rise in the price of coke. He knew two or three instances where companies had been just on the point of reducing the price of gas, but were compelled in the existing state of things to retain present rates. He could see no reason why gas companies should not raise the price of their manufactured article, when the price of the raw material was so largely increased.

Mr. GREENFIELD (Torquay) said his company had been obliged to give notice of an increase in the price of gas. The west of England suffered most severely last winter from the serious advance in the cost of coal. There was also great difficulty in getting it; and the value of the residual products did not advance correspondingly. In many towns coke had gone up considerably, but this was not the case in the west of England. There was one thing he was desirous to point out to the members of the association. It depended very much upon themselves as to the price of these products, and they ought not to commit the suicidal policy of underselling each other. If gas engineers would come to some general understanding, gas property would be in a better position.

Mr. CRAVEN (Batley) said the increased cost of coal would make a difference of £4000 a year to his company.

Mr. METHVEN (Bury St. Edmund's) read the following paper:—

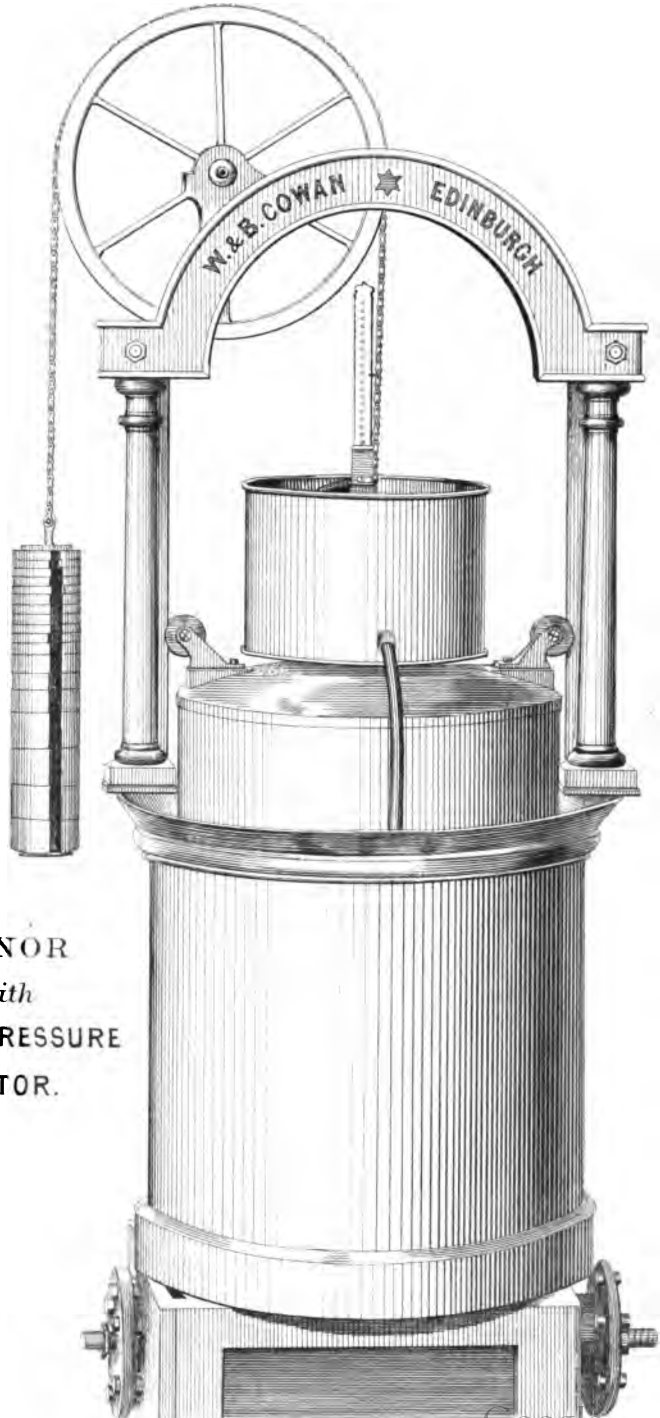
AN IMPROVED PRESSURE REGULATOR.

In gas-works in which the pressure is attended to by the foreman stoker, it frequently happens, from the hurried way in which the ordinary weights are removed from the governor or placed on it, that the sudden alteration of the pressure attracts the consumer's attention, and gives rise to an exaggerated complaint. Even although the manager may know that there was nothing worthy of much remark on the night in question, it is not always pleasant to hear the inquiry "What was the matter with the gas last night; mine nearly went out?" To remove the cause of such complaints, I have designed this simple apparatus, which, for want of a better name, I have called a Pressure Regulator. I am aware that water has been often used for this purpose, with an arrangement of cocks to draw off the water to the proper level; but I have not seen such a simple and easily adjusted arrangement as this, which I have the pleasure to introduce to the members of the Association.

The apparatus consists of a jar A, with an internal cylinder B, through which the guide-rod or chain of the ordinary governor passes, and of a piece of flexible tube, one end of which is attached to an elbow passing through the side of the jar at C, and the other end to a tube T, which is elevated or depressed by the guide-rod D. The guide-rod D has a number of holes in it, by means of which it is kept in the position required at any hour of the night.

The action is as follows:—The rod D is lifted up so that the point of the tube T is at the height required to give the maximum pressure for the night. The jar is then filled with water. When the pressure is to be reduced the attendant drops the rod D a hole, the water runs off to that level, and the pressure is reduced accordingly, and so on at each successive hour until the tube rests on the bottom of the jar and the water has all run out, and the minimum pressure is attained; the effluent water passes into the governor-tank, out of which, by an overflow-pipe, it escapes into the drain outside the building in which the governor is placed.

In order to maintain regularity in altering the pressure, a small time-piece may be attached to the jar, which by means of a cam on a spindle revolving once in twenty-four hours, will elevate and depress the tube T.



GOVERNOR
fitted with
METHVENS PRESSURE
REGULATOR.

Mr. MILES (Deane) said at the gas-works with which he was connected there had been a somewhat similar apparatus in use for the last twelve years; the only difference was that the cistern was of the same diameter as the bell—the method of getting rid of the water was the same. It was done by means of one pipe attached to the outside of the cistern, which could be lowered to a certain degree, and no more attention was needed. It had worked well, but it was after all so simple a matter that he had not thought it worth mentioning.

Mr. METHVEN quite agreed with Mr. Miles that it was hardly worth mentioning, but its very simplicity had excited the admiration of a friend, and as it had saved him some trouble he thought he might as well give the members generally the advantage of it. Ever since it was introduced he had had no complaints, and he had been able to reduce the pressure to the minimum required.

The reading of papers and discussion was then brought to a close.

ELECTION OF OFFICERS.

The SCRUTINEERS (Messrs. Eldridge and Plumbe) reported the result of their examination of the ballot-papers, and that the following gentlemen had been elected as officers, &c., for the ensuing year:—

President, Alexander Angus Croll, Esq.

Vice-Presidents, Messrs. G. T. Livesey (London), Joseph Wood (Bury), and T. N. Kirkham (London).

Treasurer, Henry Newall, Esq.

Committee (to replace the three members going off by rotation), Messrs. James Eldridge (Richmond), M. Broadhead (Great Grimsby), and J. Hutchinson (Barnsley).

Auditors, Messrs. S. P. Leather (Burnley) and A. Hersee (London).

Hon. Sec., Mr. W. H. Bennett.

PROPOSED ALTERATION OF RULE 16.

Mr. MILES (Deane), according to notice, moved "That notice of the annual meeting, with a list of the papers to be read at such meeting, be in the hands of the members twenty-one days previously." In support of the motion he urged that the alteration would afford members a longer time to consider the subjects to be discussed, and to prepare themselves to take part therein.

Mr. MILES (Clitheroe) seconded the motion.

The PRESIDENT said the committee had considered the proposed alteration, but the practical difficulties to which it would give rise prevented their recommending it. The honorary secretary had some trouble in getting a complete list of the papers to be read even within the fourteen days allowed by the present rule.

Mr. WARNER urged Mr. Miles to withdraw the motion after this intimation.

Mr. SPICE moved as an amendment—"That the present rule stand"—which being seconded by Mr. Craven, was put and agreed to almost unanimously.

Mr. MILES submitted a motion, which, however, he at once withdrew, that a portrait of the president for the time being should appear in the printed transactions of the association.

PREMIUMS FOR PAPERS.

The PRESIDENT said in his inaugural address he had thought it advisable to suggest to the association, that premiums should be offered for papers to be submitted at the annual meetings. In similar institutions that course had been adopted, and the result was to produce a better class of papers, and as this association had now funds in hand, he thought they should offer every inducement to the members to excel in their communications. There was no question that the papers read at the annual meetings, were almost the essence of the success of the association, for without them there could be no discussion and no interchange of thought on matters of practical importance and value to the members. The course which he thought it well to adopt was that the opinion of the meeting should be taken upon the principle whether it was expedient to appropriate a sum of money for the purpose, and to leave the details to be worked out by the committee, and submitted at the next annual meeting.

Mr. W. ROMANS (London) disapproved of the proposal, on the principle that he objected to read sermons which might be the production of other people, and purchased for delivery. Gas engineers should act independently, and read their own productions.

Mr. ANDERSON entertained something of the same opinion, and expressed a fear that some members who were now in the habit of contributing might not like to do so hereafter, lest it should be supposed they wrote for the sake of the premiums, and not because of the interest they felt in their profession. At the same time, if the committee found there was a difficulty in getting a sufficient number of papers at present, and that the proposal might stimulate their production, the meeting ought to support them. He took the opportunity now offered him to express regret that the remarks he had made at an early part of the meeting should have been austerely viewed by the president. He begged to say that he was proud of his acquaintance with many of the gas engineers of the metropolis, and it must not for a moment be supposed that his observations were prompted by any ill will to those gentlemen.

Mr. GODDARD agreed to some extent with Mr. Anderson in the former part of his speech. For his own part he would be very sorry to provide a paper to be read before the association with any expectation of being paid for it. At the same time he thought that by offering a premium for papers on subjects of special interest they might induce the members to direct attention more particularly to those subjects, and thus derive, as their brethren in Scotland had done, considerable benefit from the arrangement. If a trial could be made by offering premiums of 10, 15, or 20 guineas for the best papers on some specific question, it would be an excellent appropriation of the funds.

Mr. H. P. STEPHENSON thought there was a great deal of force in the remarks of Mr. Anderson, that persons might be deterred from writing papers lest they should lay themselves open to the suspicion of writing for money. If the association were to have a special medal struck to be awarded as a mark of distinction and approval, there would not be the same objection that existed to receiving a sum of money.

The PRESIDENT said it had never occurred to him that the premium should take the form of the payment of a sum of money. Premiums of this kind were generally given in medals or books. There were precedents for the course he had suggested. The Institute of Civil Engineers and the Society of Engineers, as well as other kindred institutions, were in the habit of thus marking their approval of special services. He for one would oppose *in toto* any payment of money.

Mr. PRICE (Llandudno) inquired whether he was correctly informed that the committee had had difficulty in obtaining papers.

The PRESIDENT said it was a very proper question, and one which he must answer in the affirmative. The difficulty increased year by year.

Mr. METHVEN said, when he originally made the proposition, he was aware of the difficulty experienced by the committee. He suggested that a premium might be offered for the best engine and exhauster, taking the expense of the exhauster and the arrangements into account.

Mr. H. JONES remarked that, notwithstanding the difficulty of obtaining papers, there were five on the list for the present meeting unread for want of time.

The PRESIDENT said there were only three.

Mr. PRICE then moved, and Mr. Cox (Sunderland) seconded, a motion to the effect that the association award a medal to the writer of the best paper on a subject to be selected by the committee.

Mr. SPICE thought the premium should not of necessity be a medal, and suggested that the motion read "a medal or other work of art."

Mr. PRICE accepted the suggestion.

Mr. PEEBLES spoke in favour of awarding prizes. In Scotland they were given in this shape: the persons to whom prizes were awarded were allowed to select articles of the value of the prizes. At the same time there might be members of the association to whom a money premium would be more acceptable.

Mr. WARNER hoped the members would adopt the suggestion of the president if they approved the principle, and refer it to a committee to report to the next annual meeting.

Mr. PATERSON believed that this would be the proper course to adopt.

The PRESIDENT put the motion in this form: "That this meeting adopts the principle of awarding premiums for papers, and that the details and arrangements for carrying out the object be left to the committee."

The motion was carried unanimously.

ESTABLISHMENT OF A BENEVOLENT FUND.

The PRESIDENT said the next question to which he had ventured to direct attention in his address was one of considerable importance—viz., the propriety of establishing a benevolent fund in connexion with the association. He had mentioned at the time that the gentleman whom they had now elected to succeed him offered £100 towards this object. He also reminded them that Mr. Barlow, when pointing out the necessity of establishing such a fund, promised something substantial towards it. No doubt there were other gentlemen warmly interested in the success of the association who would give something to form the nucleus of a fund of the kind. It would require considerable care in laying down the principles for its administration, and framing rules for regulating it. During the last few years a similar fund had been created in connexion with the Institute of Civil Engineers. There the matter had received a large amount of attention from gentlemen well qualified to deal with it, and they had framed a series of rules for its efficient management. It occurred to him, that if the expediency of having such a fund was recognized, it would be well to refer the question to the committee, and request them to examine that particular code of rules, to adopt them if they thought proper, or to make such amendments as they might think necessary. The association ought to deal with this question at once (under the circumstances he had named), or else allow it to lapse for a long time to come. He would move—"That in the opinion of this meeting it is desirable to form a benevolent fund, and that the arrangement and disposition of such fund and the regulations necessary for its management be referred to the committee, who shall submit a report thereon to the next meeting for adoption."

Mr. WARNER seconded the motion, and said he was most happy to think the subject was now assuming a tangible form.

Mr. BARRATT suggested that, having regard the financial position of the association, they might appropriate £100 to the object.

The PRESIDENT thought it was a very good suggestion, but one that had better be dealt with subsequently.

Mr. SIMPSON said at the last annual meeting a report from the committee which was unfavourable to the formation of such a fund was adopted. He thought it would be better, therefore, before coming to such a decision as was involved in the motion, that the same or another committee should again consider and report on the question, otherwise they would be overthrowing one year what they resolved upon the year previously, without any cause assigned. He would move as an amendment—"That before any further steps are taken in the matter, a committee be appointed to consider and report thereon."

The PRESIDENT said it must be remembered that when the question was discussed at the last meeting they had not before them the munificent offer which was now made. Everything depended upon a good start, and if the present opportunity was lost they could never with any grace take it up again. In answer to an inquiry, he said it would not be made compulsory upon the members to subscribe to the fund. It would be a purely benevolent fund, and not in the nature of a club.

Mr. CUTLER said, in the event of the fund being formed, he should be happy to give £50 towards it.

Mr. LIVESEY seconded the amendment, feeling that an opportunity should be given to reconsider the subject before any decision was arrived at. If the necessity existed for such a fund they ought to initiate it, whether money was offered for the purpose or not; if it was not necessary they should abandon the notion altogether, and give the gentlemen, who had kindly proffered help, the opportunity of disposing of their money in other directions. It was not quite correct to say that the committee reported unfavourably on the subject last year. All they did was to report the opinion of the members on the special point of inquiry. One of the four questions proposed was, "Do you know of any cases requiring the assistance such a fund would afford?" The

answer was that no such cases were known. Under such circumstances, the committee were bound to report that it would not be advisable to recommend to the association the formation of a benevolent fund.

A MEMBER said the sad case of Mr. Richards, of Wilmslow, last year, proved the necessity for such a fuud.

Mr. LIVESEY said, if a benevolent fund had been in existence, there would not have been so much money raised for Mr. Richards's family. Probably the committee of the fund might have voted £50, and persons outside might have said, we subscribe to the fund, and it is not necessary to do more.

Mr. IRONS said it was no doubt true that the members did not know of any case requiring assistance at the time the inquiry was made, but as gas managers they must often have come across instances of distress in which the help of such a fund would be most valuable. Cases frequently occurred in which relief could only be obtained through the benevolent exertions of gentlemen like Mr. Barlow in raising subscriptions. It was not right that such a matter should depend upon the personal interest of gentlemen who happened to be well known in the profession.

The amendment to refer the question to the committee for further consideration before taking any steps was then put to the meeting and lost. The motion affirming the desirableness of establishing a fund and referring it to the committee to arrange the details and report to the next meeting, was put and carried by a large majority.

PLACE AND TIME OF NEXT MEETING.

The places named were Edinburgh, Manchester, Newcastle-on-Tyne, London, Birmingham, and Leeds.

A show of hands was taken on each, and ultimately, by a large majority, it was decided that the next meeting of the association be held at Edinburgh.

On the motion of Mr. GODDARD, seconded by Mr. OHREN, it was resolved that the next meeting be held on the second Tuesday in June, 1873, and following days.

PROPOSED ALTERATION OF RULE 29.

The SECRETARY read a requisition from five members to the following effect:—"Pursuant to rule 39 we request you to bring before the association the expediency of substituting the following for rule 29—'On or before the 10th day of May in every year each member of the association shall be requested to nominate members eligible to fill the offices of president, vice-presidents, treasurer, hon. secretary, auditors, and three members of committee, in lieu of those retiring from office, such nominations shall be returned to the hon. secretary by the 20th day of May, and the list of names so nominated shall be forwarded to each member of the association before the annual general meeting. Each member to make a selection from such list, but the names so selected must not in any case exceed the number to be elected to the respective offices.'"

Mr. GODDARD said this subject had been before the committee, and had been well considered by them. The proposal appeared to be quite impracticable. The committee, as the meeting were aware, was appointed by the whole body of members, but it was found to expedite the business of the meetings that a "house list" should be prepared for the election of the various officers of the association. Attached to that list there was always a line upon which the name of any other member could be written, for whom it was desired to vote. The present system was extremely simple and effective; the alteration proposed would involve a great deal of additional labour, without any compensating advantage.

Mr. KELSALL moved as an amendment—"The existing rule be approved."

The PRESIDENT said it must be evidently undesirable to be constantly altering the rules of an association. The present rule respecting the election of officers and committee gave the members power to vote for any one they chose, and no additional power would be conferred by the proposed alteration. There were now 425 members in the association, and if circulars had to be sent to each, it would cause much increase in the work of the honorary secretary, and a great amount of confusion and obstruction in the arrangements.

The amendment was put and carried.

VOTES OF THANKS.

On the motion of Mr. WARNER, a vote of thanks was given to the scrutineers for their services.

The PRESIDENT moved—"That the best thanks of the association are due, and are hereby presented, to the Council of the Society of Arts, for their kindness in allowing the use of their rooms on the present occasion, and to Mr. Le Neve Foster, for the courtesy and consideration shown in the arrangement for the reception of members." He said the society had been extremely kind, not to this association only, but to every scientific institution, in allowing them to meet there without any expense.

The motion was duly seconded and cordially adopted.

On the motion of Mr. WOOD (Bury), thanks were voted to the gentlemen who had prepared papers and drawings to submit to the association.

On the motion of Mr. METHVEN, a cordial vote of thanks was given to the committee for their valuable services during the past year.

On the motion of Mr. SIMPSON, thanks were also tendered to Mr. Newall for his kindness in continuing to act as treasurer of the association.

Mr. GODDARD said there was another duty to be performed to which it gave him great pleasure to invite the members. He was sure they would most heartily join with him in carrying the following resolution:—"That the thanks of this meeting be presented to Jabez Church, Esq., for the very able manner in which he has conducted the business of this session, for the very admirable inaugural address which he delivered at the opening of the sittings, and also for the earnest desire he has at all times manifested to promote the prosperity of the association.

The motion was put and carried by acclamation.

The PRESIDENT: Gentlemen, if anything was wanted to complete my satisfaction in holding the office of president of this association, it has been supplied by the very cordial manner in which you have assured me of your approbation of my conduct on the present occasion. I consider it a very great honour for any member of the association to hold the office of president. I trust it will be always held in that esteem by every one, and that nothing will be at any time lacking to uphold the dignity of the position. I hope the office has not suffered in my hands. I have endeavoured, to the utmost of my ability, to serve you, and I feel myself amply repaid for any services I have rendered by the vote of thanks you have just passed.

On the motion of Mr. WARNER, it was resolved that the thanks of the association be given to Mr. W. H. Bennett for the attention bestowed by him upon the duties of his office during the past year.

Mr. BENNETT, in acknowledging the vote, said: Gentlemen, I am exceedingly obliged to you for the kind manner in which you have expressed your approval of my conduct. There is nothing which stimulates one to exertion so much as the consciousness that services rendered are cordially appreciated. I assure you that this is the effect of your vote upon me, and I can say with confidence that nothing will be wanting on my part to promote the well-being of the association.

The sitting was then brought to a close.

In the evening the members of the association and their friends (123 in number) dined together at the City Terminus Hotel, Cannon Street.

THURSDAY, JUNE 13.

This morning the members and friends proceeded by special steamer down the river to North Woolwich, from whence they were conveyed by train to Bromley, and after inspecting the new works of the Imperial Company, in course of construction, receiving the courtesy and partaking of the hospitality of Messrs. Clark and Kirkham, the engineers of the company, were reconveyed by train to North Woolwich. They then proceeded to Beckton, and visited the works of The Gaslight and Coke Company, which are now in full operation. After spending some two hours in viewing the various matters of interest in connexion with these most extensive works, the members returned to London by boat, thus bringing to a close the proceedings of the session.

APPENDIX.

The following papers presented at the Meeting of the Association were, for want of time, taken as read, and were ordered to be entered on the "Transactions":—

UTILIZATION OF BREEZE.

By JOHN SOMERVILLE, Gas-Works, Dublin.

This paper proposes to give an account of the process of converting fine breeze (which is not marketable in many places) into fuel fit for steam-boilers and furnaces in general.

In many gas-works favourably situated, managers are able to find a market and dispose of every description of products—tar, liquor, coke, breeze, ashes, refuse lime, and even clinkers, or slag—are readily bought up as fast as they are produced; while many works are cumbered with accumulations of one or other of these products of manufacture, and heaps of breeze or ashes become troublesome, because of no ready sale and have sometimes to be carted away at any price.

This was the writer's experience some few years ago, when he happened to see a machine for converting breeze into a marketable commodity by a very simple and inexpensive process, and one which yields a good commercial result.

The breeze from the ash-pans of the retort-house and coke-floor is passed through a revolving screen or sieve having a mesh half an inch wide.

And from every ten tons of breeze four tons are sold as small coke at 7s. per ton, the other six tons of fine are mixed with 150 gallons of tar, from which the naphtha has previously been taken by steam heat. This 150 gallons, or 25 gallons to the ton of breeze, is intimately mixed while warm with the breeze and put into the machine—a drawing of which you see here—and from which it is delivered in a compressed block three inches in diameter and from 9 to 12 inches long. These blocks are stacked in heaps and allowed to remain exposed to wind and sun for three weeks or a month, when they become as hard as coal, and bear cartage or transit to any distance, or can then be used in the furnaces of the retorts and steam-boilers, and when coke is in good demand at good prices, it is economy to convert breeze in this manner into fuel for carbonizing.

The heat obtained from it is quite equal to coke, and for steam-boilers it is preferable, as it gives a long lambent flame, and when judiciously manufactured and sufficiently weathered there is no smoke resulting from its combustion.

Or, if more desirable, it can be sold to users of steam power at 15s. per ton, and now that the price of steam coal is so high it might bring a higher price.

The details of manufacturing cost are as follows:—

Dr.

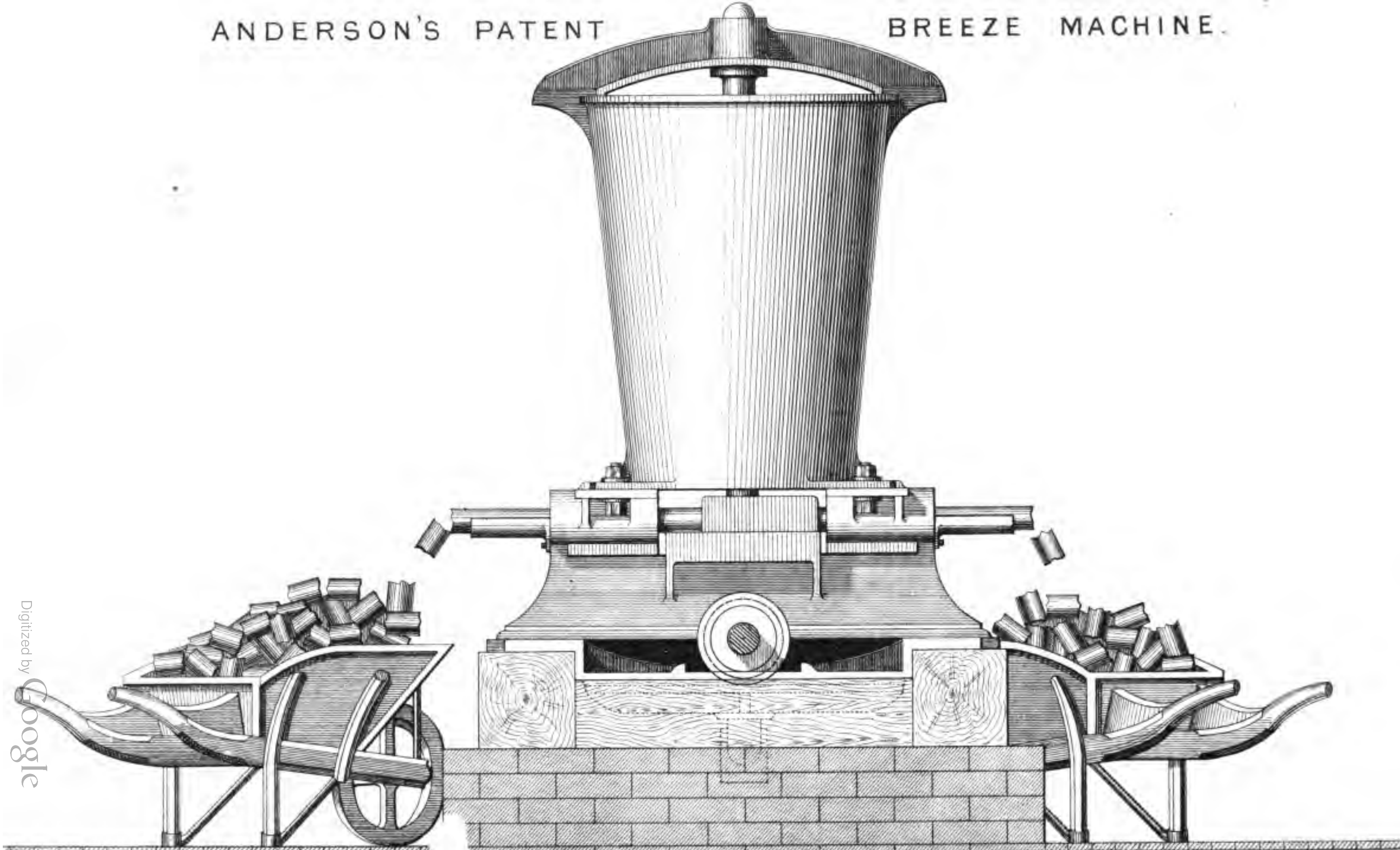
	£	s.	d.
To 10 tons of breeze, at 2s. per ton	£1	0	0
150 gallons of tar, at 1d. per gallon...	0	12	6
Screening 10 tons of breeze, at 1s. 3d. per ton	0	12	6
Working, mixing, and stacking 6·15 tons, at 3s. per ton... ...	1	0	3
One man driving steam-engine and machine, at 6d. per ton ...	0	3	4
Fuel, oil, waste, wear and tear, &c., at 6d. per ton	0	3	4
Interest on £150, cost of machine and fitting, at ½d. per ton ...	0	0	4
	£3	12	3

Cr.

By 4 tons of small coke, at 7s.	£1	8	0	
6 tons 15 cwt. of fuel, at 15s.	5	1	3	—£6 9 3

Which leaves a profit of £2 17s., or 5s. 8d. per ton of breeze, and the machine will turn out about 10 tons per day.

ANDERSON'S PATENT BREEZE MACHINE.



Litho Whiteman & Bass, 236, Holborn, London.

It is known as Anderson's patent fuel machine, and may be briefly described as a kind of pug-mill mounted above a double plunger or ram. An eccentric driven from the bottom by two strong bevel wheels gives motion to a sliding cam, to which are attached the plungers, working in corresponding compressing tubes. A shaft is continued from the eccentric through the bottom of the pug-mill, and has attached to it a number of blades for mixing more effectually the tar and breeze, which, as it descends to the bottom, is swept into two receivers by a switch blade, and, as this blade is passing over the receiver, the plunger commences its stroke, and compresses the compound through the tube into a firm solid mass, when a boy receives it, and wheels it away to the stock.

The machine can be driven by a pulley from any shafting, and requires from 6 to 8 horse power to drive it.

A sample of the fuel is here for your inspection, a piece of which has been made three months, and the other piece about three weeks.

NOTES ON THE LITHOLOGY OF GAS COALS.

By J. Paterson, Gas-Works, Warrington.

Amongst the various acquisitions desirable, if not needful, to the profession of a gas engineer, not the least important is the power of making a judicious selection of the coal used in the manufacture, whether in relation to its primary or secondary products; on this one point much of the prosperity or otherwise of gas undertakings must necessarily depend, as the profits are to be earned in the retort-house, not beyond it. It is not my intention in these notes to enter upon the natural history of coal, as the subject would occupy more of your time than I feel myself at liberty to impose, and to a less practical purpose than the object aimed at by this association; I therefore confine myself to the knowledge that may be obtained by careful observations on the external characters of a coal, which, though greatly desirable in itself, must necessarily continue to be comparatively limited, and in no case to dispense with the necessity of a carefully conducted analysis, which alone can determine its true value. There are, however, certain indications more or less defined, which, without attaching undue importance to their presence, justify at least the presumption whether the coal is suitable for gas manufacture or otherwise.

The first of these to which I venture briefly to refer is *cubical structure*, a condition which exhibits in itself many and important deviations from uniformity. It occurs stratified, massive, columnar, and in ovidal concretions, nor is the difference in their lithological characters less definite and marked; the same seam not unfrequently presents two or more distinctive bands, differing materially in their composition and quality. The two former classes contain the source from whence the chief, if not the sole supply of our gas coals is derived; these are generally divided into parallel lamina, or layers of various thickness, by what are termed "partings," consisting uniformly of a thin deposit of vegetable charcoal in the line of stratification. Vertical to these parallel lines are a succession of cracks or flaws, cutting through the stratum in the direction of its bearing line or level, generally observing a north and south polarity. These divisional lines produce a tendency to break it down into parallelopipedal masses, which presents in some cases, such as the best portions of the Wigan Arley Mine or the Silkstone full coal, very bright clean surfaces; in others, and more generally, their lustre is covered with a white sparry concretion deposited from the infiltration of calcareous water, the presence of which is not, however, objectionable in the case of a coal used for the manufacture of gas. These characters are, I believe, uniformly found to a greater or less extent in soft and easily frangible coal, and I have found them to be reliable indications of a good coking and generally of a good gas coal. On the contrary, when the mass is compact, hard, and foliated, splitting into longitudinal plates, in the line of its stratification, it will be found that the deposits of charcoal gradually disappear with the more indurated character they assume, and the vegetable remains which formed these deposits in the soft coal become in this converted to a greater or less extent into the bisulphide of iron, generally amorphous, but sometimes in the crystalline form. Their cross section is splintry or angular, the vertical cracks are only partially

present or altogether absent; under these circumstances, the coal as a general rule is better adapted for steam than for gas purposes. The coke from such coals is more compact, retains more of the structure of the coal, contains in most cases a much greater though varying per centage of ash under incineration, and frequently, but not uniformly, requires a stronger draught for its combustion.

Lustre.—This character in coal is a good and reliable evidence of its coking qualities, but less definite in relation to its gas-producing properties. All our best gas coals possess a degree of lustre more or less bright; but there are coals with a bright lustre altogether unsuited for the purpose of gas manufacture, and experience alone can identify this difference—a difference which may be said to rest upon "a shade." In order to illustrate this point we shall take the case of an anthracite which is highly lustrous, and compare it with the Wigan Arley Mine, or the resinoidal coal of the Middle Mountain Mine. A casual observer would in all probability detect no difference in their respective lustres; but in the case of the former, it partakes of a dazzling greyish metallic white, much resembling bright polished steel. In the case of the latter, they uniformly present a black, glossy, velvety surface, more or less shining according to the minutely divided matter which enters into their composition. Under a low magnifying power there are other characteristic differences brought out which would probably be more difficult to describe than to be identified by the analyst. It very frequently occurs that a mass of coal presents us with a distinct reciprocating series of bright black, alternating with bright shining and more highly lustrous bands; and from an analysis of these, I have found the former to be slightly the most favourable for the production and quality of gas, and the latter for the production and quality of coke.

Fracture and Cross Fracture.—These are distinguishing marks of a good gas coal. When gently broken they will show the fractures to be either cubical, conchoidal, semi-conchoidal, or intermediate angular, presenting a fine black pitch-like or resinoidal surface. One or more of these characters are uniformly presented by the soft and more easily frangible class of coals. On the contrary, should they be found dense, breaking with rough slaty, angular, or huckley fractures, presenting a black or greyish-black appearance, or, when broken down into small masses, present irregular and undeterminate forms, the grain will be found to be coarse, its composition more or less earthy, and the evidences unfavourable to a good gas coal.

Another well-marked and highly important character is the *streak* or shade of colour indicated upon the surface. When scratched with the point of a nail or a blunt steel point, the eroded surface will present either a dull brown, brown inclining to black, black inclining to brown, dull black, bright black, or lustrous. It will invariably be found that coal possessing either of the two former characters yields gas of a rich quality, and the more the streak approaches to a brown colour the greater will be the per centage of hydrocarbons under distillation; this character is more distinctly brought out by attrition, as the rubbing of two pieces against each other and exposing the abraded surface to the light, when the depth of the brown shade will be indicated. From a long experience I have uniformly found this to be the most positively reliable of all the external evidences we possess in approximating the value of gas coal or cannel. I have hiiherto regarded the latter indication (lustre) as evidence of their coking properties, and have generally found them to increase in that respect as the lustre becomes heightened by the streak. It does not appear, however, that these indications are reliable. I have recently had under examination a sample from the "Middle Mountain Mine" (Upholland), in which the streak is bright, but not heightened in lustre, yet this coal partakes of higher coking properties than any other that has come under my observation. The coking properties of coal may be readily and satisfactorily indicated by its combustion on the fire; open or free burning coal, under distillation, may produce a serviceable, but not a good coke; its heating power as a fuel is generally active, but not profitable. On the contrary, when the coal swells, fuses together, intumesces, and throws out jets of flame, it yields under distillation a good quality of soft coke suitable for forge, malting, or domestic purposes. Its value may be determined by incineration and carefully weighing its ash.

The specific gravity of coal expresses its density or weight in relation

to bulk or to water, as the standard unit of comparison, and, though desirable to know its weight, it affords no evidence of its composition except by inference, and this should never be resorted to when more correct information can be procured.

The amount of sulphur in combination with coal for the purpose of gas manufacture is a matter of considerable importance to the gas engineer, as any excess of that impurity involves a proportionate extent of additional purifying surface and materials. I am indebted to my friend, Dr. A. E. Davies, food analyst for the county of Worcester, for the sulphur analysis of the respective samples of coal where the per centage is given, and, though probably second to none in this department of chemical investigation, the results may or may not truly represent the normal amount of this impurity, as it frequently varies to such an extent throughout the mass that no two chemists will agree in their results taken from separate specimens of the same seam. These uncertainties lead me to adopt what may probably be considered a more reliable test in the analysis of coals for gas purposes—viz., to note the quantity of gas which a given weight of shell lime will purify, the results of which I have added to my description of the coal in each case where such a test has been applied.

The Lancashire coals, taken as a whole, are a superior class, yielding a good coke, and comparatively free from earthy or other impurities. Amongst these the Wigan Arley Mine may be regarded as the highest type of a gas and coke producing coal, and, taking these two qualities together, is probably second to none. The best sample I have had is from the Rose Bridge collieries, which are situated in or near the axis of the Wigan basin, and from a section of the *deep mine* at those works, recently sunk under the directions of Mr. Bryham, chief engineer; the depth of this seam is indicated at 2418 feet. This coal is extensively wrought about St. Helen's on the outcrop under the name of the "Little Delph," where it becomes partially intermixed with earthy matter, but still retains all the character of a good gas coal. Those from the Silkstone fall collieries are only a degree inferior to the Arley Mine, and those from Shirland collieries, Alfreton, are also of a superior quality.

Their respective analysis has been uniformly conducted under the removal of pressure from the interior of the retort to 3-10ths of an inch water column required to work the purifier. The illuminating power was in some cases taken with a fishtail burner (naked flame), but generally with the London Argand (Sugg's), 24 holes and 6-inch chimney. In each case their respective values are reduced to the weight of illuminating matter per ton by its equivalent in pounds of sperm. The desirableness of this arrangement will, I have no doubt, be appreciated, knowing the difficulty experienced in maintaining a uniform temperature throughout a series of experiments. With an elevated temperature, *quantity* is increased at the expense of quality; with a low temperature, *quality* is increased at the expense of quantity; and as two or more observations require to be made upon each coal, any difference in temperature does not practically affect the accuracy of the observations, as the weight of illuminants is the result of quantity and quality taken together. I may further add, in connexion with these tabulated weights, that 0·25 of 1d. per lb. will fairly represent the present money value of the coal at the pit; thus, a coal containing, say, 600 lbs. of illuminating matter, then $600 \times 0{\cdot}25 \div 12 = 12s.\ 5d.$ per ton; in the same way the value of one may be compared with that of another; and the arbitrary value of one farthing per pound of illuminating matter, I have here assumed, may be altered to any other unit, and applied to the series throughout.

In conclusion, I venture to observe that the accompanying tables of analysis represent, as nearly as may be arrived at by experiment, the true value of the respective coals named; but it is not to be expected that similar results will be obtained practically on the large scale when taken over the half year's working, however judicious and well-directed the management may prove to be over the carbonizing department. But the difference in the results, whatever that difference may prove to be, must not be charged against the coals, but traced to its proper cause, which, in all probability, will be influenced in many ways, such as difference in temperature, leakage from retorts, condensation through the agency of hydraulic dips, &c., all or any of which may very materially alter the conditions under which the respective distillations have been conducted.

DESCRIPTION OF COAL.

1. ALBERT GAS COAL.

(Albert Colliery Company, Newbold, Chesterfield.)

Structure of coal laminated, bright and shining, with occasional thin dark-coloured bands, cubical in all directions, soft and rather friable. Streak bright black; on the fire it intumesces and fuses, leaving a yellowish fawn-coloured ash. Its specific gravity is 1·291. The weight of one cubic foot is therefore 80·456 lbs. One cwt. of shell lime purifies about 13,000 cubic feet of gas. Coke good . . . . . .

2. ANDERTON HALL ARLEY NUTS.

(Messrs. Dewhurst, Hogle, and Smethurst.)

Characters.—Shining black, soft, and frangible. Principal fracture cubical, with thin deposits of charcoal; cross fracture cubical and conchoidal, with thin lamina of carbonate of lime, and traces of the bisulphide of iron in the crystalline form. Resinoid and conchoidal in fracture. On the fire it intumesces and fuses, leaving a light brown-coloured ash. Its specific gravity is 1·280. Weight of one cubic foot, 79,771 lbs. One cwt. of shell lime purifies about 16,000 cubic feet. Quality of coke good . . . .

3. ASTON HALL GAS COAL.

(Aston Hall Colliery Company, Hawarden, Chester.)

Characters.—Black, with shining layers, laminated, lower portion of seam containing thin dull-coloured bands, the middle and upper portion friable, possessing high coking properties. Principal fracture partially slaty and cubical, with deposits of charcoal; cross fracture cubical, with deposits of carbonate of lime. On the fire it swells and intumesces, leaving a light straw-coloured ash. Its specific gravity is 1·243. Weight of one cubic foot, 77,465 lbs. One cwt. of shell lime purifies 14,000 cubic feet of gas. Coke fair quality . . . .

4. BARLEY BROOK ARLEY COAL.

(Messrs. Pearson, Knowles, and Company, Wigan.)

This analysis was made by the late Alfred King, Esq., a name which will prove a sufficient guarantee for the accuracy, to whatever it may be attached. Specific gravity of coal (water as 1), 1·274. Sulphur per cent., 2·08 . . . .

5. BLACKLEYHURST LITTLE DELPH.

(Samuel Stock, Esq., St. Helen's.)

Characters.—Black, with bright surfaces, soft, and frangible. Fracture cubical, with minute traces of charcoal; cross fracture cubical and conchoidal, with thin lamina of carbonate of lime in vertical cracks. Streak bright black. On the fire it swells and agglutinates, leaving a pale straw-coloured ash. Its specific gravity is 1·275. Weight of one cubic foot, 79·68 lbs. One cwt. of shell lime purifies about 15,000 cubic feet of gas. Coke good . . . .

6. BRYN HALL HARD COAL.

(Messrs W. and J. B. Crippin.)

This coal is compact and foliated, presenting a dull appearance, with thin bright bands in planes of stratification. Its principal fracture is slaty, the more compact portions showing impressions of stigmaria and cryptogamic plants and deposits of charcoal in others; cross fracture partially cubical and angular. Streak bright black. Specific gravity, 1·260; consequently, the weight of a cubic foot is 78·584 lbs. This coal has been analyzed for gas purposes with favourable results, but its value consists in a higher degree in its adaptation for steam purposes. By taking the recognized formula of 967° as the latent heat cf steam, the calorific value of one lb. of coal is equal to the evaporation of 16·2 gallons of water from 212° . .

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°, Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,375	0·488	4 nearly	14·13	338·0	501·0	1402·0	3·331
11,500	0·400	4·75	14·8	355·0	583·0	1485·0	2·72
8,820	0·459	5·0	16·46	395·0	483·0	1384·0	2·38
9,500	0·460	6·0	16·7	401·0, J. P.	544·2, J. P.	1459·0	4·59
9,725	0·400	4·0	13·81	331·0	460·0	1470·0	2·75
9,540	0·511	4·0	15·28	367·0	500·0	1377·0	5·64

Description of Coal.

7. **Bryn Hall Gas Coal (Brights).**

(Messrs. W. and J. B. Crippin.)

This coal has a black shining appearance with thin dull black bands, soft and rather friable, cubical in all directions. The principal fracture contains considerable deposits of vegetable charcoal, and the cross fracture carbonate of lime. On the fire it burns with a slight intumescence, leaving a light fawn-coloured ash. Streak black, with a perceptible brown shade. Specific gravity, 1·249. Weight of one cubic foot, 77·839 lbs. Sulphur per cent., 1·132. One cwt. of shell lime purifies about 14,000 cubic feet of gas. Coke fair heating quality . . . .

8. **Clifton Hall Coal.**

(Messrs. Thompson, Simpson, & Co., Stockport.)

This coal is massive, black, and shining, compact, and columnar. Parallel with its plane of bedding it presents a uniform series of striated and grooved markings, similar to the abrasion of rock surfaces from the Icefloes of the Glacial Epoch Its principal fracture is cubical, with deposits of charcoal; cross fracture cubical, with lamina of carbonate of lime. Streak brownish black. On the fire it swells, fuses, and intumesces, leaving a brownish-yellow coloured ash. Its specific gravity is 1·289. Weight of one cubic foot, 80·330 lbs. One cwt. of shell lime purifies about 15,000 cubic feet of gas. Coke good . . . .

9. **Dutton Middle Mountain Mine Coal.**

(Dutton Coal and Iron Company, Upholland, Wigan.)

Characters.—Bright shining black, rather friable, with bands of bright lamina throughout. Fracture uneven and cubical, containing thin deposits of charcoal; cross fracture cubical and intermediate angular. Streak not heightened in lustre; on the fire it swells, intumesces, and fuses together, leaving a yellowish-brown coloured ash. Its specific gravity is 1·222. Weight of one cubic foot, 76·156 lbs. One cwt. of shell lime will purifiy about 15,000 cubic feet of gas. Coke very superior . . . .

10. **Garswood Hall Top Coal.**

(Dewhurst, Hoyle, and Smethurst, Wigan.)

Characters.—Coal black and shining, with alternating thin dull black bands, soft and friable, cubical in all directions. The principal fracture contains layers of charcoal and deposits of lime, with traces of the bisulphide of iron in the amorphous form in its cross fracture. On the fire it intumesces slightly, leaving a light fawn-coloured ash. Streak black, inclining to brown. Specific gravity, 1·244. Weight of one cubic foot, 77·527 lbs. One cwt. of shell lime purifies about 13,000 cubic feet of gas. Coke fair quality . . . .

11. **Garswood Little Delph.**

(Messrs. D. Bromilon and Co., St. Helen's.)

This coal is similar to that described in No. 5. Its specific gravity is 1·276. Weight of one cubic foot, 79·75 lbs. Sulphur per cent., 0·768 . . . .

12. **Haddock Little Delph.**

(Messrs. R. Evans and Co., St. Helen's.)

This coal is also similar to that described in No. 5. Its specific gravity is 1·274. Weight of one cubic foot, 79·62 lbs. The Little Delph does not appear to vary much in the St. Helen's district; in such case one cwt. of shell lime is sufficient to purify about 15,000 cubic feet of gas, and the coke is invariably good . . . .

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°. Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,800	0·458	4·5	16·14	387·0	597·0	1324·0	5·5
10,730	0·575	6 nearly.	17·30	415·0	636·44	1464·0	3·33
10,055	0·513	4·25	17·26	414·0	595·0	1470·0	1·73
10,820	0·566	4·0	16·0	384·0	593·56	1346·0	5·79
9,000	0·417	4·0	14·74	354·0	455·17	1419·0	3·0
8,936	..	4·0	12·75	306·0	391·0	13·98	3·03

Description of Coal.

13. **Hindley Field Best Coal.**

(R. S. Norris, Esq.)

Coal black and shining, stratified with dull black bands. Principal fracture slaty and cubical, with deposits of charcoal; cross fracture cubical, with lamina of carbonate of lime; rather friable. On the fire it burns freely with a slight intumescence, leaving a pale straw-coloured ash. Streak bright black. Specific gravity, 1·252. Weight of one cubic foot, 78·026 lbs. One cwt. of shell lime purifies about 13,000 cubic feet of gas. Coke fair quality . . . .

14. **Hindley Field Four Feet.**

(R. S. Norris, Esq.)

Coal black and massive, streaked with dull and shining bands. Principal fracture cubical, with considerable deposits of charcoal; cross fracture cubical, with carbonate of lime, friable and easily disintegrated. Streak bright black. On the fire it intumesces slightly, leaving a dirty white-coloured ash. Its specific gravity is 1·248. Weight of one cubic foot, 77,776 lbs. One cwt. of shell lime purifies about 13,000 cubic feet of gas. Coke fair quality . . . .

15. **Hindley Green Arley Mine.**

(Messrs John Scowcroft and Co.)

Characters.—Black, with bright surfaces. Principal fracture cubical, with deposits of vegetable charcoal; cross fracture cubical, with considerable deposits of thin lamina of carbonate of lime; soft and easily frangible. On the fire it agglutinates and intumesces, leaving a light-brown coloured ash. Its specific gravity is 1·268. Weight of one cubic foot, 79,022 lbs. One cwt. of shell lime purifies about 17,000 cubic feet of gas. Coke good . . . .

16. **Hindley Green Five Feet.**

(Edward Johnson, Esq., St. Helen's.)

Colour of coal black, cubical, streaked with shining bands; lower portion of the seam containing a band of variable thickness, partaking of the character of cannel in an inferior degree, yielding a larger per centage of hydrocarbons with a smaller quantity of gas (at equal temperature). Principle fracture slaty, with deposits of charcoal; cross fracture cubical. On the fire it swells and intumesces, leaving a light-coloured ash. Its specific gravity is 1·292. Weight of one cubic foot, 80·519 lbs. Per centage of sulphur, 3·431. One cwt. of shell lime purifies about 14,000 cubic feet of gas. Coke good . . . .

17. **New Winning Orrell Four Feet.**

(Messrs. J. Blundell and Son, Wigan.)

Coal bright black, streaked with thin black shining bands, cubical in all directions. Its principal fracture contains deposits of charcoal with thin lamina of carbonate of lime, and traces of the bisulphide of iron in cross fracture. Streak brownish black. On the fire it agglutinates and intumesces, leaving a light brown-coloured ash. Specific gravity, 1·266. Weight of one cubic foot, 78·898 lbs. One cwt. of shell lime purifies about 14,000 cubic feet of gas. Coke good quality . .

18. **New Winning Orrell Five Feet.**

(Messrs. J. Blundell and Son, Wigan.)

Coal massive, bright, and streaked with bright black shining bands, cubical in all directions. Its principal fracture contains considerable deposits of charcoal; in cross fracture are lamina of carbonate of lime and bisulphide of iron, chiefly in the crystalline forms. Streak black, inclining to brown. On the fire it agglutinates and fuses sparingly, leaving a light brown-coloured ash. Its specific gravity is 1·268. Weight of one cubic foot, 79·023 lbs. One cwt. of shell lime purifies about 12,000 cubic feet of gas. Coke fair quality . . . .

Purified Gas per Ton of Coal in Cubict Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°. Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,760	0·450	4·22	15·26	366·0	562·0	1314·0	5·45
10,750	0·462	5·0	15·35	368·0	565·75	1374·0	7·77
11,200	0·452	4·0	15·11	366·0	585·6	1435 0	2·28
9,470	0·479	4·0	13·35	320·4	409·1	1315·0	3·21
10,975	0·469	4· nearly	16·97	407·0	638·43	1464·0	4·33
11,800	0·481	3·5	13·92	334·0	563·0	1461·0	5·88

DESCRIPTION OF COAL.

19. NEW WINNING WIGAN FOUR FEET.

(*Messrs. J. Blundell and Son, Wigan.*)

Upper portion of the seam rather soft and friable, under portion containing dull bands of a more indurated character. Principal fracture slaty and partially cubical, with vegetable impressions; cross fracture cubical and sub-angular, with bisulphide of iron in its crystalline form, and traces of carbonate of lime. Streak black, inclining to brown. On the fire it splits and fuses slightly, leaving a light fawn-coloured ash. Its specific gravity is 1·271. Weight of one cubic foot, 79·21 lbs. One cwt. of shell lime purifies about 11,000 cubic feet of gas. Coke fair quality .

20. NEW WINNING KING COAL TOPS.

(*Messrs. J. Blundell and Son, Wigan.*)

This coal is columnar, and rests in a bed of *stigmaria* having dividing planes parallel to its base. Principal fracture cubical and sub-angular, with thin deposits of vegetable charcoal; cross fracture cubical, with lamina of carbonate of lime and occasionally of bisulphide of iron. Streak brownish black. On the fire it agglutinates and intumesces strongly, leaving a brownish fawn-coloured ash. Specific gravity, 1·259. Weight of one cubic foot 78·462 lbs. One cwt. of shell lime purifies about 12,000 cubic feet of gas. Coke fair quality . . . .

21. NEW WINNING KING COAL BOTTOMS.

(*Messrs. J. Blundell and Son, Wigan.*)

Coal black and partially shining, pretty uniform in structure throughout. Principal fracture partially cubical and angular, containing deposits of charcoal, and traces of vegetable remains converted into bisulphide of iron; cross fracture cubical, carbonate of lime and traces of pyrites. Streak black, inclining to brown. On the fire it fuses and intumesces, leaving a rather light fawn-coloured ash. Specific gravity, 1·262. Weight of one cubic foot, 78·65 lbs. One cwt. of shell lime purifies about 10·500 cubic feet of gas. Coke fair quality . . . .

22. PEASLEY CROSS LITTLE DELPH.

(*Messrs. Bourne and Robinson.*)

This coal is similar to that described in No. 5. Its specific gravity is 1·275. Weight of one cubic foot, 79·46 lbs. Sulphur not identified . . . .

23. PLATT LANE COAL.

(*Wigan and Whiston Coal Company, Limited.*)

Colour of coal black, massive shining layers, lower portion containing hard dull-coloured bands, having a specific gravity of 1·301; top portion shining and friable. Principal fracture partially slaty, with charcoal deposits; cross fracture cubical, thin deposits of carbonate of lime interspersed throughout its mass. On the fire it opens and intumesces, leaving a straw-coloured ash. Average specific gravity, 1·289. Weight of one cubic foot, 80·332 lbs. Coke good, rather hard. . . . .

24. ROSE BRIDGE ARLEY MINE COAL.

(*G. Grant Morris, Esq., Wigan.*)

Characters.—Black, with bright clean surfaces. Principal fracture cubical with occasional traces of vegetable charcoal; cross fracture cubical and intermediate angular, occasional deposits of carbonate of lime, but very free from impurities or foreign matter; sectile, but not frangible; resinoid in all directions. Streak brownish black. On the fire it swells, intumesces, and fuses, leaving a fawn-coloured ash. Its specific gravity is 1·273. Weight of one cubic foot, 79·334 lbs. Sulphur, 1·116 per cent. One cwt. of shell lime purifies about 17,000 cubic feet of gas. Coke very good . . . .

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°, Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,150	0·489	3·5	14·63	351·0	509·12	1400·0	6·13
10,300	0·487	3·75	14·53	349·0	513·53	1460·0	5·22
10,000	0·477	3·6	14·48	348·0	497·0	1431·0	5·33
9,000	0·411	..	12·5	300·0	386·0	1425·0	4·75
9,750	0·483	3·5	13·75	330·0	459·64	1412·0	2·94
12,600	0·445	5·0	15·4	370.0	666·0	1493·0	1·71

Description of Coal.

25. **Rose Bridge Deep Yard Coal.**

(*G. Grant Morris, Esq.*)

Characters.—Bright black and laminated. Principal fracture cubical and flatly conchoidal, with bright shining surfaces, deposits of charcoal or thin lamina of the bisulphide of iron in the lines of parting, the latter only occasional; cross fracture cubical, with thin lamina of carbonate of lime. Streak black, inclining to brown. On the fire it swells, slightly agglutinates, and intumesces, leaving a brownish white-coloured ash. Its specific gravity is 1·271. Weight of one cubic foot, 79·21 lbs. Coke good. . . . .

26. **Shirland Gas Coal.**

(*Shirland Colliery Company, near Alfreton.*)

Characters.—Black and shining. Principal fracture cubical, with partial deposits of charcoal; cross fracture cubical and conchoidal, resinoid in every direction, indicating a coal of superior coking properties. On the fire it swells, intumesces, and fuses, leaving a pale straw-coloured ash. Its specific gravity is 1·265. Weight of one cubic foot, 78·836 lbs. One cwt. of shell lime purifies about 16,000 cubic feet of gas. Coke very good . . . .

27. **Shirland Tipton Gas Coal.**

(*Shirland Colliery Company.*)

Coal bright black and rather friable, with bands of bright lamina throughout. Fracture cubical, with slight traces of charcoal; cross fracture cubical and resinoid. Streak bright black. On the fire it swells and agglutinates, leaving a yellowish coloured ash. Its specific gravity is 1·261. Weight of one cubic foot, 78·586 lbs. One cwt. of shell lime purifies about 16,000 cubic feet of gas. Coke very good. .

28. **Silkstone Fall Coal.**

(*Silkstone Fall Coal Company, Barnsley.*)

Coal highly bituminous, under portion of the seam compact, presenting the appearance and lithological conditions of cannel in a secondary degree, passing into a more fragile and soft state in the upper portion, which contains thin deposits of charcoal in its lines of stratification. Its colour is a bright shining black. Principal fracture conchoidal and partially irregular; cross fracture hackley, angular, shining, and highly resinoid in every direction. Streak bright black, inclining to brown. On the fire it swells, fuses, and intumesces, leaving a small residue of straw-coloured ash. Its specific gravity is 1·206. Weight of one cubic foot, 75·159 lbs. Sulphur, 1·32 per cent. One cwt. of shell lime purifies about 17,000 cubic feet of gas. Coke good . . . .

29. **Silkstone Fall Best Thorncliffe.**

(*Silkstone Fall Coal Company.*)

The external characters of this coal are very closely allied with that of the Wigan Arley Mine; it presents bright black clean surfaces. Principal fracture cubical, with slight traces of charcoal; cross fracture cubical and hackley, very free from impurities. Resinoid in all directions. Streak blackish brown. On the fire it swells, agglutinates, and intumesces, leaving a light fawn-coloured ash. Its specific gravity is 1·285. Weight of one cubic foot, 80·082 lbs. Sulphur per cent., 1·6. One cwt. of shell lime purifies about 17,000 cubic feet of gas. Coke good . . . .

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°, Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,300	0·444	5·25	15·22	365·3	537·51	1315·0	2·3
11,000	..	4·25	13·46	323·0	507·0	1312·0	1·85
9,800	0 500	5·0	16·22	389·0	545·0	1402·0	1·77
11,290	..	6·28	16·98	407·0	656·43	1443·0	0·81
11,290	0·476	6·25	17·0	408·0	652·8	1431·0	1·8

Description of Coal.

30. **Silkstone Top Bed.**

(*Silkstone Fall Coal Company.*)

Coal black with shining surfaces, uniform in structure throughout, presenting a jet-like appearance. Fracture cubical in all directions, occasional traces of carbonate of lime and vegetable charcoal, easily frangible. Streak black, inclining to brown. On the fire it swells, fuses, and intumesces, leaving a light brownish-yellow coloured ash. Its specific gravity is 1·273. Weight of one cubic foot, 79·334 lbs. Sulphur per cent., 1·25. One cwt. of shell lime purifies about 17,000 cubic feet of gas. Coke good . . . .

31. **Spring Colliery, The Yard Coal.**

(*Messrs. Pearson and Knowles, Wigan.*)

Colour shining black, under portion of the seam streaked with thin bright bands. Principal fracture partially slaty and cubical, containing deposits of charcoal, and occasionally thin lamina of vegetable matter, converted into iron pyrites, cross fracture cubical, with deposits of carbonate of lime. On the fire it swells and intumesces, leaving a fawn-coloured ash. Its specific gravity is 1·291. Weight of one cubic foot, 80·456 lbs. One cwt. of shell lime purifies about 14,000 cubic feet of gas. Coke good . . . .

32. **Spring Colliery Smith Coal.**

(*Messrs. Pearson and Knowles, Wigan.*)

Colour of coal shining black, soft and liable to disintegration. Principal fracture cubical, with deposits of charcoal in the lines of stratification; cross fracture cubical, with thin deposits of carbonate of lime, occasionally oxidized with moisture, having traces of iron in solution. On the fire it swells, agglutinates, and intumesces, leaving a yellowish coloured ash. Its specific gravity is 1·203. Weight of one cubic foot, 74·972 lbs. One cwt. of shell lime purifies about 16,000 cubic feet of gas. Coke very good . . . .

33. **Staveley Gas Coal.**

The lower band of this coal, and the most superior portion, is bright black, hard, and laminated. Principal fracture slaty and semi-angular; cross fracture splintry and irregular; upper portion cubical in all directions, with thin bands of charcoal, carbonate of lime, and iron pyrites. Streak black. On the fire it splits and flies slightly, and burns freely without intumescence, leaving a reddish light brown-coloured ash. Its average specific gravity is 1·280. Weight of one cubic foot, 79·771 lbs. One cwt. of shell lime purifies about 13,000 cubic feet of gas. Sulphur per cent., 1·015. Coke fair quality. Upper portion. . . . .
Lower portion . . . .

34. **Swan Lane Gas Coal, Hindley.**

(*Edward Johnson, Esq., St. Helen's.*)

Colour bright black, laminated, soft, and easily disintegrated. Quality uniform throughout the thickness of the seam. Principal fracture slaty and cubical, with deposits of charcoal; cross fracture cubical, with thin deposits of carbonate of lime. On the fire it intumesces and agglutinates, leaving a light straw-coloured ash. Its specific gravity is 1·242. Weight of one cubic foot, 77·403 lbs. Sulphur per cent., 1·135. One cwt. of lime purifies about 13,000 cubic feet of gas. Coke good.

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°, Barom. 30°.	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
11,670	0·440	4·5	15·17	364·0	606·84	1395·0	2·0
10,450	0·477	5·0	13·31	319·0	476·22	1456·0	3·62
9,800	0·494	5·3	15·22	365·0	511·39	1463·0	2·11
9,040	..	..	11·52	270·0	350·0	1395·0	4·32
10,100	..	..	12·23	294·0	424·0	1340·0	4·5
9,400	0·521	4·73	16·82	404·0	542·5	1314·0	2 42

	Description of Coal.
35.	**Syndal Hall Bone Coal.** (*Dewhurst, Hoyle, and Smethurst, Wigan.*) Black, shining, compact, and columnar. Parallel with its plane of bedding, it presents uniformly a series of striated and grooved markings, similar to the Clifton Hall coal. It is called *shutty coal* by the miners, who suppose it to have been deposited on the side of a basin, and when in a pasty or semi-fluid state, to have shot or slipped down, leaving the abraded and grooved surfaces to form the matrice of the succeeding deposit. I am disposed, however, to think it is due to chemical or electrical agency rather than to the cause assigned. Its fracture is cubical in all directions. Streak black, in lower portion inclining to brown. On the fire it swells, fuses, and intumesces, leaving a brownish-yellow coloured ash. Its specific gravity is 1·291. Weight of one cubic foot, 80·456 lbs. One cwt. of shell lime purifies about 15,000 cubic feet of gas. Coke good . . . .
36.	**Victoria Arley Coal.** (*Victoria Colliery Company, Rainford.*) Black and shining. Principal fracture cubical and angular, with deposits of charcoal and occasional traces of bisulphide of iron; cross fracture cubical and conchoidal, with thin deposits of carbonate of lime, partially resinoid, indicating a coal of good coking properties. On the fire it swells, intumesces, and partially fuses, leaving a light straw-coloured ash. Its specific gravity is 1·260. Weight of one cubic foot, 78·524 lbs. One cwt. of lime purifies about 15,000 cubic feet of gas. Coke good . . . .

Purified Gas per Ton of Coal in Cubic Feet.	Specific Gravity of Gas, Air as 1. Temp. 60°, Barom. 30°,	Matter Condensable by Bromine per Cent.	Illuminat. Power of Gas in Spm. Candles of 120 Grs.	Value of Gas in Grains of Sperm per Cubic Foot.	Illuminat. Matter per Ton of Coal in lbs. of Sperm.	Weight of Coke in lbs. per Ton of Coal.	Ash in Coke per Cent.
10,150	0·542	6·0	17·8	434·0	630·0	1291·0	3·22
10,030	0·483	4·52	13·63	327·0	454·26	1264·0	2·88

British Association of Gas Managers.

LIST OF SUBSCRIPTIONS, &c.,

Paid during the Year ending April 30, 1872.

DONATION.

Mr. Thos. Hawksley	London	£5	5	0

ANNUAL SUBSCRIPTIONS.

Mr. J. Lyne	Wexford	£0	10	6
„ J. Jowett	Leeds	0	10	6
„ T. Hardick	Salisbury	1	1	0
„ J. B. Spence	Manchester	0	10	6
„ J. Martin	Ormskirk	0	10	6
„ Jos. Deakes	Worcester	1	1	0
„ E. Baker	Reading	0	10	6
„ J. Morris	Jersey	1	1	0
„ E. L. Ridgway	Abingdon	0	10	6
„ J. Niven	Clayton	0	10	6
„ H. B. Billows	Queenstown	1	1	0
„ T. Newbigging	Pernambuco	1	1	0
„ J. L. Cocker	Merthyr Tydfil	0	10	6
„ W. J. Moon	Peterborough	1	1	0
„ R. Dempster	Elland	0	10	6
„ J. Foxall	Beverley	0	10	6
„ G. A. Robinson	Leicester	1	1	0
„ C. S. Robinson	Leicester	1	1	0
„ W. P. Throsby	Lincoln	1	1	0
„ B. G. Venner	Eton	0	10	6
„ W North	Stourbridge	1	1	0
„ T. Smith	Wigan	1	1	0
„ E. Price	Hampton Wick	0	10	6
„ J. Wadeson	Windsor	0	10	6
„ D. Hunter	Greenwich	1	1	0
„ E. Evans	Peterborough	0	10	6
„ Geo. Anderson	London	1	1	0
„ J. Macnie	Londonderry	1	1	0
„ W. Pritchard	St. Helen's	1	1	0
„ R. Price	Llandudno	1	1	0
„ J. Hale	Ballymena	0	10	6
„ Jas. Rich	Devonport	0	10	6
„ T. Rafferty	Manchester	1	1	0
„ W. Shimeld	Dundalk	0	10	6
	Carried forward	£26	15	6

Brought forward		£26	15	6
Mr. G. Severs	Birstall	0	10	6
„ J. Marsland	Enniskillen	0	10	6
„ J. Hutchinson	Barnsley	0	10	6
„ M. Martin	Drogheda	0	10	6
„ T. Anderson	Bath	0	10	6
„ H. Cockey	Frome	1	1	0
„ C. H. Hutchinson	Barnsley	0	10	6
„ W. J. Warner	South Shields	0	10	6
„ J. Miles	Deane	0	10	6
„ J. R. Smith	Padiham	0	10	6
„ W. Miles	Clitheroe	0	10	6
„ R. Darney	Faversham	0	10	6
„ H. O. Eldridge	Richmond	0	10	6
„ M. Broadhead	Great Grimsby	0	10	6
„ J. Storer	Stafford	0	10	6
„ D. Brandwood	Radcliffe	0	10	6
„ W. Fraser	Inverkeithing	0	10	6
„ *E. White	Birmingham	0	10	6
„ D. Lane	Cork	1	1	0
„ D. Helps	Bath	0	10	6
„ R. Cooper	Banbury	0	10	6
„ A. F. Phillips	St. Albans	1	1	0
„ W. Foulis	Glasgow	1	1	0
„ W. Stout	Boston	0	10	6
„ A. Donaldson	Edinburgh	1	1	0
„ P. H. Wilkinson	Harrogate	0	10	6
„ T. Varley	Colne	0	10	6
„ J. W. Baker	Limerick	1	1	0
„ W. W. Hutchinson	Barnsley	0	10	6
„ J. Laycock	Keighley	0	10	6
„ W. Ford	Stockton-on-Tees	1	1	0
„ J. H. Cox	Sunderland	1	1	0
„ D. Clark	Sunderland	0	10	6
„ G. A. Allan	Newcastle	0	10	6
„ W. Smith, jun.	Hyde	0	10	6
„ Jos. Wood	Bury	1	1	0
„ R. H. Jones	Dover	1	1	0
„ C. Craven	Dewsbury	0	10	6
„ J. Meiklejohn	Dungannon	0	10	6
„ A. Gibb	Lurgan	0	10	6
„ Geo. Garnett	Ryde	1	1	0
„ M. Ohren	Sydenham	1	1	0
„ E. S. Cathels	Sydenham	1	1	0
„ Jas. Harris	Ross	1	1	0
„ S. Hunter	Louth	0	10	6
„ Robt. Gill	Bridgnorth	0	10	6
„ W. Blackledge	Bacup	0	10	6
„ J. Middleton	Wandsworth	0	10	6
„ J. Russell	Uxbridge	0	10	6
„ G. B. Vanheson	Rochester	0	10	6
„ R. Gardiner	Newcastle	0	10	6
„ F. Beale	Beckton	0	10	6
„ W. Blackburn	Hebden Bridge	0	10	6
„ W. C. Rafarel	Barnstaple	1	1	0
Carried forward		£63	0	0

* By an error on the part of the person who received the subscriptions at the Meeting in Dublin, this was entered as 10*s.* 6*d.*, whereas it should have been £1 1*s.* 0*d.*

		Brought forward	£63	0	0
Mr.	R. Harris	Bow	2	2	0
„	J. W. O'Neill	London	1	1	0
„	J. Johnson	London	1	1	0
„	E. Genever	Dunedin	0	10	6
„	L. Hislop	Ayr	0	10	6
„	W. Box	Crayford	0	10	6
„	A. Barton	Cowes	1	1	0
„	Jas. Edmond	Newtown	0	10	6
„	Geo. Scott	Tunbridge Wells	0	10	6
„	Jas. Hunter	Woolwich	1	1	0
„	H. W. Andrews	Dublin	0	10	6
„	J. Wilson	Abingdon	0	10	6
„	J. Randall	Tottenham	0	10	6
„	S. Studholm	Whitehaven	1	1	0
„	W. B. Whitaker	Belper	0	10	6
„	T. M. Harris	Falmouth	0	10	6
„	F. Philpots	Dursley	0	10	6
„	H. S. Pierson	London	1	1	0
„	W. Ambler	Saltaire	0	10	6
„	W. S. Whitehead	Bradford	1	1	0
„	Robt. Iddon	Southport	0	10	6
„	H. Manning	Hythe	0	10	6
„	W. B. Emmerson	Portadown	1	1	0
„	W. Barratt	Accrington	0	10	6
„	J. G. Dear	Baldock	0	10	6
„	T. H. Bouttell	Sleaford	0	10	6
„	H. G. Crowe	Wellington	0	10	6
„	G. M. Ford	Exeter	0	10	6
„	P. W. Hastings	London	0	10	6
„	T. Giles	Cowes	0	10	6
„	Robt. King	London	1	1	0
„	W. A. Padfield	High Wycombe	1	1	0
„	C. R. Mead	Reigate	1	1	0
„	C. Hawksley	Westminster	1	1	0
„	J. Douglas	Portsea	2	2	0
„	E. Goddard	Ipswich	1	1	0
„	F. Williams	London	1	1	0
„	M. H. Loam	Nottingham	0	10	6
„	F. Bower	Low Moor	0	10	6
„	Allan Brown	Woodford	1	1	0
„	Jas. Eadington	Blyth	0	10	6
„	J. H. Cornish	Bridgwater	0	10	6
„	J. Hepworth	Carlisle	0	10	6
„	W. Wood	Cambridge	0	10	6
„	S. Cutler	Millwall	1	1	0
„	A. H. Wood	Hastings	1	1	0
„	C. R. Robinson	Coventry	1	1	0
„	W. L. Robinson	Coventry	1	1	0
„	G. D. Malam	Halifax	1	1	0
„	J. Clark	King's Cross	1	1	0
„	H. Clark	Haggerston	1	1	0
„	Jos. Reed	Newport	0	10	6
„	W. A. Plumbe	Sutton in Ashfield	0	10	6
„	H. W. Smith	Seaham Harbour	0	10	6
„	W. Daniel	Dublin	0	10	6
„	W. H. Catlin	Dublin	0	10	6
		Carried forward	£107	2	0

	Brought forward		£107	2	0
Mr.	W. Fleming	Lancaster	0	10	6
,,	P. J. Wates	Loughborough	0	10	6
,,	J. Braddock	Droylsden	0	10	6
,,	A. C. Fraser	Middlesbrough	1	1	0
,,	E. Smith	Droitwich	0	10	6
,,	P. Simpson	Rugby	0	10	6
,,	F. Child	Sheffield	0	10	6
,,	A. H. Still	Cork	1	0	0
,,	C. Taylor	Derby	0	10	6
,,	Jas. Hodgson	Ulverstone	0	10	6
,,	J. West	Maidstone	0	10	6
,,	A. Potter	Willington Quay	1	1	0
,,	F. J. Stevens	London	2	2	0
,,	W. H. Chambers	Lowestoft	0	10	6
,,	C. Tadman	Norwich	0	10	6
,,	J. H. Robinson	Leamington	1	1	0
,,	Jos. Phelps	Marlborough	0	10	6
,,	Robt. Fish	Hornsey	1	1	0
,,	H. Warsop	Nottingham	0	10	6
,,	G. J. Parkinson	Birmingham	1	1	0
,,	A. Williams	London	1	1	0
,,	C. Copland	Hull	0	10	6
,,	T. Stone	Weymouth	0	10	6
,,	Geo. Payne	Millwall	1	1	0
,,	Geo. Helps	Bath	0	10	6
,,	A. Dougall	Kidderminster	0	10	6
,,	Chas. Hunt	London	0	10	6
,,	W. T. Carpenter	Sheerness	0	10	6
,,	Edgar Church	Huntingdon	0	10	6
,,	T. H. Methven	Bury St. Edmund's	1	0	0
,,	Jas. Jenkin	Southampton	1	1	0
,,	Geo. Waller	London	0	10	6
,,	F. Doughty	Margate	0	10	6
,,	A. E. Baron	King's Lynn	0	10	6
,,	W. Wright	Lewes	0	10	6
,,	J. Moir	Newbiggin	0	10	6
,,	R. Brown	Arbroath	0	10	6
,,	Henry Newall	Manchester	1	1	0
,,	Jas. Stelfox	Belfast	1	1	0
,,	J. Cowen	Blaydon	0	10	6
,,	J. Murray	Graingerville	0	10	6
,,	W. C. Humphrys	New Barnet	0	10	6
,,	J. Tindall	Walsall	0	10	6
,,	E. H. Harris	Wallasey	0	10	6
,,	S. Cross	Abergavenny	0	10	6
,,	R. Little	Louth	0	10	6
,,	T. W. R. White	Sherborne	0	10	6
,,	E. Baker	Reading	0	10	6
,,	J. Dunning	Middlesbrough	1	0	0
,,	W. R. Hammond	Deal	0	10	6
,,	A. Penny	London	1	1	0
,,	J. Cockcroft	Littleborough	0	10	6
,,	D. Laidlaw	Glasgow	0	10	6
,,	J. Read	Tunbridge Wells	0	10	6
,,	J. Aird, jun.	London	0	10	6
,,	J. Booth	Stalybridge	0	10	6
	Carried forward		£145	5	6

	Brought forward		£145	5	6
Mr.	J. W. Lawson	South Shields	0	10	6
,,	T. May	Canterbury	0	10	6
,,	W. U. Tinney	Winchester	1	1	0
,,	J. R. Frith	Runcorn	0	10	6
,,	T. A. Drew	Widnes	0	10	6
,,	Geo. Rait	Blackheath	1	1	0
,,	W. Moor	Fence Houses	0	10	6
,,	R. Morton	London	0	10	6
,,	Jabez Church	London	1	1	0
,,	J. W. Pollard	London	1	1	0
,,	W. Davis	Hereford	1	1	0
,,	T. Livesey	London	1	1	0
,,	Geo. Livesey	London	1	1	0
,,	T. Bull	Tamworth	0	10	6
,,	Jas. Hislop	Glasgow	1	1	0
,,	C. Wright	Saffron Walden	0	10	6
,,	J. Somerville	Dublin	1	1	0
,,	J. T. B. Porter	Lincoln	0	10	6
,,	A. Kitt	London	0	10	6
,,	G. Thorneloe	London	0	10	6
,,	T. R. Mellor	London	0	10	6
,,	J. Ohren	Rio de Janeiro	0	10	6
,,	W. P. Wilson	London	0	10	6
,,	J. Kelsall	Ashton-under-Lyne	1	1	0
,,	A. M. Murphy	Cirencester	0	10	6
,,	J. Greenfield	Torquay	0	10	6
,,	E. Brickles	Santiago	0	10	6
,,	J. Wilton	Silvertown	1	1	0
,,	T. N. Kirkham	London	2	2	0
,,	C. Woodhall	London	1	1	0
,,	E. Chatwood	Ramsbottom	0	10	6
,,	T. Dand	Exeter	0	12	0
,,	I. A. Crookenden	London	0	10	6
,,	R. J. Fennesey	London	0	10	6
,,	W. Dore	Neath	0	10	6
,,	R. O. Paterson	Cheltenham	1	1	0
,,	T. Forest	Walker	0	10	6
,,	W. Hildrith	Darlington	0	10	6
,,	J. Lowe	Bridport	0	10	6
,,	J. Mudie	Burton-on-Trent	0	10	6
,,	J. M. Darwin	Longton	0	10	6
,,	L. H. Green	Dartford	0	10	6
,,	F. J. Evans	London	1	1	0
,,	W. C. Holmes	London	1	1	0
,,	G. C. Trewby	Beckton	1	1	0
,,	C. Kitto	Tunbridge	0	10	6
,,	J. Stevenson	Dublin	1	1	0
,,	J. B. Spence	Manchester	1	1	0
,,	R. Dempster	Elland	1	1	0
,,	C. Farrand	Croydon	0	10	6
,,	W. Fiddes	Bristol	1	1	0
,,	R. Church	Chichester	0	10	6
,,	H. Bartholomew	Glasgow	1	1	0
,,	W. H. Willis	Great Yarmouth	0	10	6
,,	R. J. Niven	Kettering	0	10	6
,,	A. F. Livesay	Chale	1	1	0
	Carried forward		£187	17	6

	Brought forward		£187	17	6
Mr.	J. G. Livesay	Ventnor	0	10	6
,,	J. Blackburn	Calcutta	1	1	0
,,	A. Hersee	London	0	10	6
,,	T. Pearson	Portland	0	10	6
,,	J. E. Clift	Redditch	2	2	0
,,	W. T. Walker	London	1	1	0
,,	J. Donaldson	Dover	2	2	0
,,	T. Bell	Selby	0	10	6
,,	H. P. Stephenson	London	1	1	0
,,	F. Leslie	Moscow	1	1	0
,,	J. M'Millan	Newry	0	10	6
,,	W. Romans	London	1	0	0
,,	J. T. Hall	Prescot	1	1	0
,,	J. M. Jameson	Fleetwood	1	1	0
,,	Hy. Green	Preston	0	10	6
,,	H. T. Everist	Red Hill.	0	10	6
,,	W. Longworth	Dukinfield	0	10	6
,,	T. Trewhitt	West Hartlepool	1	1	0
,,	J. Paterson	Warrington	1	1	0
,,	J. Burgess	Huddersfield	0	10	6
,,	H. Veevers	Bolton	2	2	0
,,	J. Reid	Derby	0	10	6
,,	W. Osmond	Dorchester	0	10	6
,,	R. Douglas	Newcastle	1	1	0
,,	C. Horsley	London	0	10	6
,,	Thornton Andrews	Swansea	1	1	0
,,	H. Lyon	Manchester	0	10	6
,,	T. Melling	Rainhill	1	1	0
,,	E. R. Blanchett	London	0	10	6
,,	W. Parlby	Aylesbury	1	1	0
,,	J. Methven	Birmingham	1	1	0
,,	H. Brothers	London	0	10	6
,,	J. Arnott	Leeds	1	1	0
,,	S. P. Leather	Burnley	1	1	0
,,	J. Annan	Wolverhampton	0	10	6
,,	J. B. Ball	Yeovil	0	10	6
,,	H. Bowen	Cardiff	1	1	0
,,	W. Bailey	Camborne	1	0	0
,,	T. H. Martin	Crewe	0	10	6
,,	W. Wright	Shipley	0	10	6
,,	H. B. Billows	Queenstown	1	0	0
,,	W. Duff	Morecambe	0	10	6
,,	J. Rowan	Colchester	0	10	6
,,	S. B. Darwin	Shrewsbury	1	11	6
,,	T. Newbigging	Pernambuco	1	1	0
,,	J. B. Coulson	London	0	10	6
,,	H. Woodall	Longport	0	10	6
,,	J. Martin	Ormskirk	0	10	6
,,	A. Upward	London	3	3	0
,,	J. Lyne	Wexford	0	10	6
,,	W. J. Larkum	Ripon	0	10	6
,,	T. Hughes	Slough	1	1	0
,,	W. Prescott	Prescot	1	1	0
,,	R. P. Spice	London	1	1	0
			£236	11	0

SALE OF REPORTS.

Mr.	W. B. Whitaker	Belper	£0	4	6
„	F. H. Smith	Bilston	0	4	9
„	Jas. Paterson	Warrington	2	14	0
„	J. M'Millan	Newry	0	9	6
„	R. Price	Llandudno	0	18	0
„	G. M. Ford	Exeter	0	3	2
„	P. W. Neumann	Bergen	0	8	3
„	A. Gibb	Lurgan	0	18	0
„	Rogers & Co.	London	0	17	3
„	G. M. Ford	Exeter	0	4	6
„	J. Jenkin	Southampton	0	9	0
„	J. Tindall	Walsall	0	4	6
„	C. Eastwood	Dewsbury	0	4	6
„	F. H. Smith	Moxley	0	4	6
„	P. W. Neumann	Bergen	0	4	6
„	R. Iddon	Southport	0	18	0
„	D. M. Nelson	Glasgow	0	9	1
„	J. Paterson	Warrington	1	11	6
„	W. Coward	London	0	4	6
„	H. Smythe	Cardiff	0	13	4
„	W. B. King	London	0	16	4
„	J. Methven	Birmingham	0	12	10
„	T. Tallentine	Lisburn	1	2	9
„	A. Hersee	London	0	4	6
„	L. Monk	Edinburgh	0	17	3
			£15	19	0

ENTRANCE FEES.

Mr.	J. W. O'Neill	London	£5	0	0
„	D. Laidlaw	Glasgow	5	0	0
			£10	0	0

BRITISH ASSOCIATION OF GAS MANAGERS.

BALANCE-SHEET, APRIL 30, 1872.

Dr.

	£	s.	d.
April 30, 1871.			
To Balance brought forward	249	13	7
April 30, 1872.			
To Annual Subscriptions	236	11	0
,, Donation from T. Hawksley, Esq.	5	5	0
,, Sale of Reports	15	19	0
,, Entrance Fees.	10	0	0
,, Interest allowed by Treasurer on Balance	9	19	8
	£527	8	3

Cr.

	£	s.	d.
April 30, 1872.			
By Printing, Stationery, and Postages	47	8	8
,, Expenses of Meeting in Dublin	17	18	4
,, Expenses of Excursion	18	10	0
,, Dr. Letheby's Fee and Expenses	17	3	3
,, Printing, Lithographing, Binding Reports, and Advertising	65	7	6
,, Carriage of Parcels and Sundry Expenses	9	14	1
,, Amount Voted to Honorary Secretary	50	0	0
,, Balance in Treasurer's hands	301	6	5
	£527	8	3

Examined and found correct,

May 13th, 1872. (Signed) SAMUEL P. LEATHER, A. HERSEE, } *Auditors.*

BRITISH

Association of Gas Managers.

RULES AND REGULATIONS

AND

LIST OF MEMBERS.

JUNE, 1872.

Office-Bearers.—1872-73.

President.

ALEXANDER ANGUS CROLL, D.L., J.P., 10, Coleman Street, London, E.C.

Vice-Presidents.

THOMAS NESHAM KIRKHAM, Imperial Gas Company's Works, Fulham, London, S.W.

GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.

JOSEPH WOOD, Gas-Works, Bury, Lancashire.

Trustees.

EBENEZER GODDARD, Gas-Works, Ipswich.

THOMAS HAWKSLEY, 30, Great George Street, Westminster.

HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.

Treasurer.

HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.

Hon. Secretary.

WILLIAM H. BENNETT, 42, Parliament Street, London, S.W.

Committee.

ISAAC A. CROOKENDEN, Phœnix Gas Office, Bankside, London, S.E.

JABEZ CHURCH, 17B, Great George Street, Westminster, S.W.

GEORGE GARNETT, Gas-Works, Ryde, Isle of Wight.

JOHN SOMERVILLE, Alliance Gas-Works, Great Brunswick Street, Dublin.

HARRISON VEEVERS, Gas-Works, Bolton.

ALFRED UPWARD, 11, Great Queen Street, Westminster, S.W.

MATTHEW BROADHEAD, Gas-Works, Great Grimsby.

JAMES ELDRIDGE, Gas-Works, Richmond, Surrey.

JOHN HUTCHINSON, Gas-Works, Barnsley.

The following are, *ex officio*, also Members of the Committee:—

ALEXANDER ANGUS CROLL, 10, Coleman Street, London, E.C.

EBENEZER GODDARD, Gas-Works, Ipswich.

THOMAS HAWKSLEY, 30, Great George Street, Westminster, S.W.

THOMAS NESHAM KIRKHAM, Imperial Gas Company's Works, Fulham, London, S.W.

GEORGE T. LIVESEY, South Metropolitan Gas-Works, Old Kent Road, London, S.E.

HENRY NEWALL, Ducie Buildings, Bank Street, Manchester.

JOSEPH WOOD, Gas-Works, Bury, Lancashire.

WILLIAM H. BENNETT, 42, Parliament Street, Westminster, S.W.

Auditors.

SAMUEL P. LEATHER, Gas-Works. Burnley.

ALFRED HERSEE, 39, Old Broad Street, London, E.C.

REGULATIONS.

SECTION I.—Object.

1.—This Association shall devote itself to the encouragement and advancement of all matters connected with Gas Engineering, Manufacture, and Finance—being established to facilitate the exchange of information and ideas among its Members.

SECTION II.—Constitution.

2.—This Association shall consist of Ordinary, Extra-Ordinary, and Honorary Members.

3.—Ordinary Members shall be either Engineers, Managers, or Secretaries of Gas-Works, who may make application for membership and be admitted.

4.—Extra-Ordinary Members shall consist of gentlemen taking an interest in matters connected with Gas-Works, and shall only be admitted upon being elected at the Annual General Meeting of the Association by a majority of two-thirds of the Members present, and will be allowed to take part in its proceedings. Besides paying the usual Annual Subscription, they will pay an Admission Fee of £5.

5.—Honorary Members shall be gentlemen who take a deep interest in matters connected with Gas Engineering, and whose scientific or practical knowledge recommends them to the Association.

SECTION III.—Management.

6.—The Management of the affairs of the Association shall be confided to a Committee, subject to the control of the General Meetings.

7.—The Officers shall consist of a President, three Vice-Presidents, Treasurer, Honorary Secretary, and nine Members of Com-

mittee, to be elected at the General Meeting, in the manner hereinafter directed. The President, Past President, or Acting President for the preceding year, Vice-Presidents, Treasurer, Trustees, and Honorary Secretary shall be *ex officio* members of the Committee. Five to be a quorum.

SECTION IV.—DUTIES OF OFFICE-BEARERS.

8.—The Office-bearers shall assume office immediately after the meeting at which they are elected. They shall hold meetings, and make arrangements for carrying out the objects of the Association.

9.—The President shall take the chair at all meetings at which he is present. He shall conduct and keep order, state and put questions, and, if necessary, ascertain the sense of the meeting upon matters before them. He may sum up, at the termination of discussions, the opinions given, and declare what appears to be the object or intention of the speaker, to which he may add his own opinion; and he shall carry into effect the regulations of the Association.

10.—The Vice-Presidents shall take part in the proceedings, and one of them shall take the chair in the absence of the President, and perform the duties enumerated in the preceding regulation. In the absence of the President and Vice-Presidents, a Chairman to be nominated from the other members of the Committee.

11.—The Secretary shall, on being appointed, receive all moneys, and hand the same to the Treasurer. He shall also take minutes of the proceedings at all the meetings of the Association, and enter them in proper books provided for the purpose. He shall write the correspondence, read minutes and notices at all the meetings, and also papers and communications, if the authors wish it, report discussions, and perform whatever other duties may be indicated in the regulations of the Association as appertaining to his department.

12.—The duties of the Treasurer shall be to keep in safe custody the funds of the Association, and to make all necessary payments by cheques signed by three of the Committee.

SECTION V.—AUDITORS.

13.—Two Auditors, who shall be Members of the Association, but not Office-bearers, shall be chosen at each General Meeting, to examine the accounts and statements produced by the Secretary and Treasurer.

SECTION VI.—MEETINGS AND PROCEEDINGS.

14.—The Association shall hold General Meetings annually, at such time and place as shall be arranged at the previous General Meeting.

15.—At every General Meeting of the Association, the Secretary shall first read the minutes of the preceding meeting, which, on approval, shall be signed by the Chairman; the Secretary shall next read any notices or papers which may be brought before the meeting, after which new Members shall be admitted. Any business of the Association shall then be disposed of, and any communications or papers for the day be read.

16.—The Secretary shall issue notices to all Members of the Association at least fourteen days before each General Meeting, mentioning the papers to be read, and the business to be brought forward at the meeting.

17.—The Committee shall meet one hour before each meeting of the Association, and on other occasions when the President shall deem it necessary, of which notice shall be given by special circulars.

18.—All questions to be decided by any convenient system of open voting, the Chairman to have a second or casting vote when necessary. Questions of a personal nature shall be decided by ballot.

19.—Any Member, with the concurrence of the Chairman, shall have power to admit a friend to each meeting of the Association, but who shall not take any part in the discussions, unless requested to do so by the Chairman of the Meeting.

20.—All papers read at the meetings of the Association must relate to matters either directly or indirectly connected with the objects of the Association, and must be approved of by the Committee before being read.

21.—All papers, drawings, or models submitted to these meetings shall remain the property of their authors, and the Association shall afford every facility for giving this rule practical effect.

SECTION VII.—ELECTION OF NEW MEMBERS AND OFFICE-BEARERS.

22.—Every applicant for membership shall signify the same in writing to the Secretary, who shall, thereafter, submit it to the Committee, to be considered and brought by them before the next meeting of the Association for approval.

23.—Honorary Members shall be proposed to or by the Committee, and notice thereof shall be given by the Secretary at the next meeting of the Association, who shall admit them, if approved by two-thirds of the Members present.

24.—New Members to be formally introduced by the Chairman after being elected, when their names shall be entered in a roll-book of the Association, and they shall at the same time receive a copy of the regulations.

25.—If any person proposed for membership, on being balloted for, be rejected, no notice shall be taken of the proposal in the minutes.

26.—The President, Vice-Presidents, Treasurer, and Secretary shall be elected annually.

27.—The President shall in no case hold that office for a longer period than one year; and, at the expiration of such period, he shall not be re-eligible for that office for the period of three years.

28.—Three Members of the Committee shall retire annually in rotation, and be ineligible for re-election during the following year.

29.—The Committee shall, previous to the Annual Meeting in each year, prepare a list of Members whom they nominate as suitable for the offices of President, Vice-Presidents, Treasurer, and Honorary Secretary for the ensuing year. The list shall also contain the names of twelve Members whom the Committee nominate as fitted to become Members of the Committee. A copy of such list to be forwarded to each Member of the Association before the

Annual General Meeting, and each Member shall be at liberty to make a selection from the list, or to substitute the name or names of any other Member or Members for each respective office; but the number of names so selected or substituted must not in any case exceed the number to be elected to the respective offices.

SECTION VIII.—CONTRIBUTIONS OF MEMBERS TO THE ASSOCIATION.

30.—Every Ordinary and Extra-Ordinary Member shall contribute the sum of not less than 10s. 6d. annually.

31.—Honorary Members shall not be required to pay any contributions.

32.—The Annual Contributions shall be payable in advance, at or before each General Meeting.

33.—No Member whose contribution is in arrear shall be entitled to vote.

34.—Any Member retiring from the Association shall continue to be liable for annual contributions which shall have accrued due previously to the time at which he shall have given written notice of his retirement to the Secretary.

35.—Any Member may compound for his Annual Subscription by the payment in one sum of Ten Guineas. All such compositions shall be invested in the names of three Trustees, and the interest alone shall be appropriated to the current expenditure of the Association, except by special direction of the Committee.

SECTION IX.—BYE-LAWS.

36.—Any proposition for adding to or altering the regulations shall be laid before the Committee, who may bring it before the Association, if they think fit, and who shall be bound to do so on the requisition, in writing, of any five Members of the Association.

37.—Each Member of the Association shall be annually furnished by the Secretary with a copy of the Rules and Regulations, and also with a list of the names and residences of the Members.

BRITISH ASSOCIATION OF GAS MANAGERS.

LIST OF MEMBERS.

The Figures preceding the Names indicate the Date of Election.

Honorary Members.

	Name.	Address.
1864	Barlow, Thos. G. (*Past President*)	42, Parliament Street, Westminster, S.W.
1866	Durand, Emile	72, Faubourg Montmartre, Paris
1864	Hawksley, Thomas (*Trustee and Past President*)	30, Great George Street, Westminster, S.W.
1864	Letheby, Dr.	17, Sussex Place, Regent's Park, London, N.W.
1864	Muspratt, Dr.	Duke Street, Liverpool
1868	Odling, Dr.	Royal Institution, 21, Albemarle Street, London, W.
1864	Rofe, John..	7, Queen Street, Lancaster

(*Number of Honorary Members*, 7.)

Ordinary Members.

1866	Allan, Geo. A.	Gas-Works, Willington Quay, near Newcastle-upon-Tyne
1871	Ambler, William	Gas-Works, Saltaire, Bradford
1866	Anderson, Geo.	19, Northumberland Street, Charing Cross, London, W.C.
1868	Anderson, Thomas	Gas-Works, Bath
1871	Andrews, Henry Ward	Alliance Gas-Works, Sir John Rogerson's Quay, Dublin
1864	Andrews, Thornton	Gas-Works, Swansea
1866	Annan, John	Gas-Works, Wolverhampton
1867	Arnott, John	53, Belle Vue Road, Leeds
1868	Backler, Henry M'L.	11, Austin Friars, London, E.C.
1871	Bailey, William	Gas-Works, Camborne, Cornwall

	Name.	Address.
1868	Baker, Edward	Gas-Works, Reading
1871	Baker, John William	United General Gas Company's Office, 101, George Street, Limerick
1868	Ball, John B.	Gas-Works, Loughborough
1872	Barclay, David	Gas-Works, Tottenham, N.
1870	Barratt, William	Gas Office, Accrington
1871	Barton, Alfred	Union House, West Cowes, Isle of Wight
1864	Bartholomew, H.	157, St. Vincent Street, Glasgow
1867	Bates, William	Gas-Works, Worksop
1870	Beale, Frederick	Gas-Works, Beckton, North Woolwich, E.
1864	Bell, Thomas	Gas-Works. Selby
1872	Berry, George	Gas-Works, Ashford
1864	Billows, H. B.	Gas-Works, Queenstown, Ireland
1868	Binks, Joshua	Gas-Works, Gomersall, near Leeds
1864	Blackburn, James	Gas-Works, Calcutta
1864	Blackburn, William	Gas-Works, Hebden Bridge
1864	Blackledge, William..	Gas-Works, Bacup
1870	Blanchett, Edward Richard ..	Gas-Works, Georgetown, British Guiana
1865	Booth, Jun., John	Gas-Works, Middlesborough
1867	Bouttell, Thos. Hy.	Gas-Works, Sleaford
1864	Bowen, Henry	Gas-Works, Cardiff [near Bradford
1870	Bower, Frederick	Gas-Works, Low Moor, North Bierley,
1871	Box, William W.	Gas-Works, Crayford, Kent
1869	Braddock, James	Gas-Works, Droylsden, near Manchester
1864	Braddock, Sen., Joseph	105, Windsor Road, Oldham
1864	Brandwood, D...	Gas-Works, Radcliffe, near Manchester
1872	Brett, Robert William	Gas-Works, Hertford
1867	Brickles, Edward	Gas Works, Santiago, Chili
1872	Broadberry, William Henry ..	Gas-Works, Southend
1864	Broadhead, M. (*Member of Committee*)	Gas-Works, Great Grimsby
1872	Brothers, Francis William ..	Gas-Works, Calcutta
1869	Brothers, Horatio	Gas-Works, Lupus Street, Pimlico, London, S.W.
1867	Brothers, Orlando	Gas-Works, Blackburn
1871	Brown, Allan	Gas-Works, Woodford, Essex
1866	Brown, John	Gas-Works, Waltham Cross, London, N.
1864	Brown, Robert	Gas-Works, Arbroath
1867	Brown, William	30, Oxford Street, Manchester
1872	Bryan, Eli..	Gas-Works, Sandbach, Cheshire
1867	Bull, Thomas	Gas-Works, Tamworth

	Name.	Address.
1867	Burgess, John	Gas-Works, Huddersfield
1868	Carpenter, W. T.	Gas-Works, Sheerness
1864	Cathels, E. S.	New City Gas Company's Works, Montreal, Lower Canada.
1871	Catlin, William Henry	Alliance Gas-Works, Dublin
1865	Chambers, W. H.	Gas-Works, Lowestoft
1867	Chattwood, Edmund	Gas-Works, Ramsbottom
1870	Child, Frederick	Bank View, 158, Crooks Moor Road, Sheffield
1864	Church, Edgar	Gas-Works, Huntingdon
1864	Church, Jabez (*Past President and Member of Committee*)	17B, Great George Street, Westminster, and Gas-Works, Chelmsford
1864	Church, Robert	Gas-Works, Chichester
1868	Clark, David	Gas-Works, Hendon, Sunderland
1869	Clark, David	Gas-Works, Brymbo
1870	Clark, Henry	Imperial Gas-Works, Haggerston, London, E.
1870	Clark, John	Imperial Gas-Works, King's Cross, London, N.
1872	Clark, Richard	Gas-Works, Truro, Cornwall
1872	Clarke, David	Gas-Works, Glossop, Derbyshire
1870	Clift, John Edward	Gas-Works, Redditch
1868	Cocker, John Lees	Gas-Works, Merthyr Tydvil
1865	Cockey, Henry	Gas-Works, Frome
1867	Cockcroft, John	Gas-Works, Littleborough
1864	Cooper, W. R.	Gas-Works, Banbury
1867	Copland, Jun., Charles	Orwell House, Beverley Road, Hull
1870	Cornish, James Hughes	Gas-Works, Bridgwater
1869	Coulson, James B.	Independent Gas Office, 236, Kingsland Road, London, E.
1866	Cox, John H.	Gas-Works, Sunderland
1872	Cranmer, Job Seymour	Gas-Works, Malton, Yorkshire
1864	Craven, Charles A.	Gas-Works, Dewsbury
1867	Croll, A. Angus (*President*)	10, Coleman Street, London, E.C.
1869	Crookenden, Isaac Adolphus (*Member of Committee*)	Phœnix Gas Office, 69, Bankside, London, [S.E
1870	Cross, Samuel	Gas-Works, Abergavenny
1872	Crossley, Thomas C.	Gas-Works, Guernsey
1867	Crowe, Henry G.	Gas-Works, Wellington, Somerset
1872	Currie, Joseph Allan	Gas-Works, Waltham Cross, N.

	Name.	Address.
1872	Cutler, George	New Gas-Works, Whitehaven
1864	Dand, Thomas	Gas-Works, Exeter
1872	Daniel, Thomas Henry	Gas-Works, Congleton
1871	Daniel, William	55, Mary Street, Dublin
1868	Darney, Robert..	Gas-Works, Faversham
1869	Darwin, James Malam	Gas-Works, Longton, Staffordshire
1867	Darwin, S. B.	Gas-Works, Shrewsbury
1867	Davies, John	Gas-Works, Kidsgrove
1868	Davis, William	Gas-Works, Hereford
1867	Deakes, Josiah	Gas-Works, Worcester
1871	Dear, James Gilbert..	Gas-Works, Baldock, Herts
1864	Dempster, R.	Gas Engineer, Elland
1872	Dixon, Charles	Gas-Works, Horncastle, Lincolnshire
1867	Donaldson, John	Gas-Works, Dover
1871	Dougall, Andrew	Gas-Works, Kidderminster
1872	Dougall, Archibald	Gas-Works, Elgin
1870	Doughty, Frederick	Gas-Works, Margate
1866	Douglas, John	Gas-Works, Portsea
1866	Douglas, Robert	Redheugh Hall, Gateshead
1868	Douglas, Thomas	Gas-Works, Barnet
1865	Dore, William	New Gas Company, Neath, South Wales
1870	Drew, Thomas Allen	Gas-Works, Widnes, near Warrington.
1870	Duff, William	Gas-Works, Morecambe
1864	Dunning, John	Middlesbrough
1869	Eadington, James	Gas-Works, Blyth, Northumberland
1871	Edmond, James..	Gas-Works, Newtown, Montgomeryshire
1872	Edson, George	Gas-Works, Otley, near Leeds
1870	Eldridge, Henry Oswald	Gas-Works, Richmond, Surrey
1865	Eldridge, James (*Member of Committee*	Gas-Works, Richmond, Surrey
1869	Emmerson, William Barnes ..	Gas-Works, Darlington.
1872	Eunson, Jun., John..	Gas-Works, Northampton
1870	Evans, Edward	Gas-Works, Shrewsbury.
1870	Evans, Frederick John	Chartered Gas-Works, Horseferry Road, Westminster, S.W.
1868	Everist, Henry Thomas	56, Nelson Square, Blackfriars Road, London, S.E.
1872	Farrand, Frank Frederick ..	Gas-Works, Caterham Valley, Surrey
1870	Farrand, Charles	Gas-Works, Croydon

	Name.	Address.
1869	Fennesey, Rodney J.	39, Old Broad Street, London, E.C.
1865	Fiddes, Walter	Gas-Works, Bristol
1864	Fingland, John	Gas-Works, Todmorden
1870	Fish, Robert	Gas-Works, Hornsey, London, N.
1864	Fleming, W.	Gas-Works, Lancaster
1868	Ford, Geo. Mortimer	Gas Engineer, Commercial Road, Exeter
1868	Ford, William	Gas-Works, Stockton-on-Tees
1868	Forrest, Thomas	Gas-Works, Walker, near Newcastle-upon-Tyne
1868	Foster, Charles	
1870	Foulis, William	Gas Office, 42, Virginia Street, Glasgow
1864	Foxall, John	Gas-Works, Beverley
1864	Fraser, A. C.	Rectory House, Martin's Lane, Cannon Street, London, E C.
1864	Frith, J. R.	Gas-Works, Runcorn
1869	Gardiner, Ralph	Elswick Engine-Works, Newcastle-upon-Tyne
1864	Garnett, George (*Member of Committee*)	Gas-Works, Ryde, Isle of Wight
1871	Genever, E.	Gas-Works, Dunedin, New Zealand
1871	Gibb, Andrew	Gas-Works, Oswestry
1864	Giles, Thomas	Gas-Works, Cowes, Isle of Wight
1872	Gill, Joshua	Gas-Works, Dawley, Shropshire
1870	Gill, Robert	Gas-Works, Bridgnorth, Salop
1872	Goddard, D. Ford	Gas-Works, Ipswich
1864	Goddard, E. (*Trustee and Past President*)	Gas-Works, Ipswich
1872	Goldsmith, George	Gas-Works, Leicester
1872	Good, Robert	Gas-Works, Carshalton, Surrey
1870	Goodwin, James	Gas-Works, Rotherham
1869	Gore, Henry	
1872	Green, Benjamin	Gas-Works, Mitcham, Surrey
1869	Green, Henry	Gas-Works, Preston, Lancashire
1864	Green, L. H.	Gas-Works, Dartford, Kent
1864	Green, Thomas	Gas-Works, Heckmondwike
1871	Greenfield, James	Hollacombe, Paignton, Devon
1872	Grimwood, Charles William ..	Gas-Works, Sudbury
1869	Hale, John	Gas-Works, Ballymena, Ireland
1864	Hall, J. T...	Prescot, Lancashire
1864	Hammond, W. R.	Gas-Works, Deal
1872	Hancock, Peter..	Gas-Works, Middlewich, Cheshire

	Name.	Address.
1866	Hardick, Thos.	Gas-Works, Salisbury
1872	Hardie, William	Gas Office, Newcastle-on-Tyne
1869	Harding, George	Broad Green, near Liverpool
1867	Harris, Edmund H.	Gas-Works, Wallasey, Birkenhead
1871	Harris, Frederick Mole	Gas-Works, Falmouth
1869	Harris, James	Gas-Works, Ross, Herefordshire
1870	Harris, Robert	Gas-Works, Bow Common, London, E.
1870	Hastings, Peter Williams ..	16, Patshull Road, N.W.
1866	Hawksley, Charles	30, Great George Street, Westminster, S.W.
1872	Hegarty, John	Gas-Works, Colombo, Ceylon
1868	Helps, Daniel	Gas-Works, Bath
1870	Helps, George	Gas-Works, Bath
1868	Hepworth, Joseph	Gas-Works, Carlisle
1868	Hersee, Alfred	39, Old Broad Street, London, E.C.
1872	Hersey, Thomas	Halesworth House, Massie Road, Dalston, [E.
1864	Hildreth, William	Colliery Offices, Darlington
1872	Hislop, George R.	Gas-Works, Paisley
1864	Hislop, James	9, Neilson Terrace, Wilson Street, Hillhead, Glasgow
1869	Hislop, Laurence	Gas-Works, Ayr
1865	Hodgson, James	Gas-Works, Ulverston
1871	Hollwey, John	Springfield, Glenageary, Kingstown, Ireland
1869	Holmes, William Cartwright ..	Iron-Works, Huddersfield
1866	Hughes, Thos.	
1870	Humphrys, William Chilton ..	Gas-Works, Albert Road, New Barnet, N.
1870	Hunt, Charles	London Gas Company's Works, Nine Elms, London, S.W.
1866	Hunter, David	2, Cambridge Villas, South St., Greenwich, [S.E.
1866	Hunter, James	Consumers' Gas Company, Woolwich, S.E.
1869	Hunter, Samuel	Gas-Works, Rochdale
1871	Hutchinson, Charles Henry ..	New Gas-Works, Barnsley
1864	Hutchinson, John (*Member of Committee*)	Gas-Works, Barnsley
1867	Hutchinson, Walter W.	Gas-Works, Barnsley
1871	Iddon, Robert	Gas-Works, Southport
1866	Irons, Geo. B.	Gas-Works, Gosport
1869	Jameson, J. M...	Gas-Works, Fleetwood, Lancashire
1871	Jenkin, James	Gas-Works, Southampton
1868	Johnson, John	Chartered Gas Company, 9, Water Street, Blackfriars, London, E.C.

	Name.	Address.
1872	Jones, Charles W.	Gas-Works, Genoa
1869	Jones, E. E.	Gas-Works, Buxton, Derbyshire
1870	Jones, H. M. Layard	25, Old Broad Street, London, E.C.
1866	Jones, Hodgson	67, Victoria Street, Westminster, S.W.
1872	Jones, Walter R.	Gas-Works, Glasgow
1872	Jones, William J.	Gas-Works, Malta
1866	Jones, Robert H.	Gas-Works, Dover
1870	Jowett, James	Gas Works, Leeds
1867	Kelsall, Isaac	Gas-Works, Ashton-under-Lyne
1871	King, Robert	8, St. Mary Axe, London, E.C.
1872	King, Robert	Stratford Road, Wolverton
1868	Kirkham, Thos. N. (*Vice-President*)	Imperial Gas Company's Works, Fulham, London, S.W.
1870	Kitt, Alfred	Chartered Gas-Works, Horseferry Road, Westminster, S.W.
1870	Kitto, Charles William	Gas-Works, Tunbridge, Kent
1872	Laing, Robert	Independent Gas-Works, 236, Kingsland Road, London, E.
1871	Lane, Denny	72, South Mall, Cork
1864	Larkum, W. J.	Gas-Works, Ripon
1870	Lawson, John Wilkinson ..	Gas Office, South Shields
1867	Lawson, William	
1868	Laycock, John	Gas-Works, Keighley
1864	Leather, S. P.	Gas-Works, Burnley
1866	Leslie, Frederick	Gas-Works, Moscow
1869	Little, Robert	Gas-Works, Louth, Lincolnshire.
1870	Littlehales, Thomas	West London Junction Gas-Works, Wormwood Scrubs, London, W.
1868	Livesay, Augustus F.	Chale, Isle of Wight
1865	Livesay, John G.	Gas-Works, Ventnor, Isle of Wight
1864	Livesey, George T. (*Vice-President*)	South Metropolitan Gas-Works, Old Kent Road, London, S.E.
1866	Loam, M. H.	Gas-Works, Nottingham
1864	Longworth, William	Gas-Works, Dukinfield
1872	Lord, Edmund	Gas-Works, Whitworth, Rochdale
1866	Lowe, James	Gas-Works, Bridport
1869	Lyne, John	Gas-Works, Wexford, Ireland
1866	Lyon, Henry	Gas-Works, Rochdale Road, Manchester

	Name.	Address.
1872	Macfarlane, J. R.	Gas-Works, Gaythorne Station, Manchester
1869	M'Millan, John	Gas-Works, Stoke-on-Trent
1869	Macnie, John	Gas-Works, Londonderry, Ireland
1864	M'Pherson, Hugh	Gas-Works, Newcastle-upon-Tyne
1866	Malam, Geo. Dunbar	Gas-Works, Halifax
1871	Manning, Henry	Gas-Works, Hythe, Kent
1872	Markham, Thomas T.	Gas-Works, Kingston-upon-Hull
1869	Marsland, John..	Gas-Works, Enniskillen, Ireland
1864	Martin, John	Gas-Works, Ormskirk
1869	Martin, Michael	Gas-Works, Drogheda, Ireland
1871	Martin, Thomas Henry	Gas-Works, Crewe, Cheshire
1868	May, Thomas	Gas-Works, Canterbury
1872	Medhurst, Jun., William ..	Gas-Works, Folkestone
1869	Mead, Charles Roper	Wray Park, Reigate, Surrey
1871	Meiklejohn, James	Gas-Works, Portadown, Armagh, Ireland
1869	Melling, Thomas	Gas-Works, Rainhill, Lancashire
1869	Mellor, Thomas Randolph ..	Rectory House, Martin's Lane, Cannon Street, London, E.C.
1870	Methven, John..	Gas-Works, Windsor Street, Birmingham
1864	Methven, T. H.	Gas-Works, Bury St. Edmund's
1870	Middleton, John	Gas-Works, Wandsworth, Surrey, S.W.
1867	Miles, John	Deane, near Bolton, Lancashire
1867	Miles, William	Gas-Works, Clitheroe
1870	Moir, John	Gas-Works, Newbiggin
1865	Moon, Wm. Jas.	Gas-Works, Peterborough
1869	Moor, William	Hetton Colliery, near Fence Houses
1872	Moor, William	Gas-Works, Hetton, Durham
1868	Morris, Joseph	Gas-Works, Jersey
1872	Mortis, William John	Gas-Works, Eltham, Kent, S.E.
1864	Morton, Robert..	London Gas-Works, Nine Elms, London, [S.W.
1872	Mossman, Thomas	Gas-Works, West Hartlepool
1864	Mudie, John	Gas-Works, Burton-on-Trent
1872	Muriel, George	Ottoman Gas-Works, Smyrna
1864	Murphy, A. M...	Gas-Works, Cirencester
1870	Murray, John	Graingerville, Newcastle-on-Tyne
1864	Newall, Henry (*Trustee and Treasurer*)	Ducie Buildings, Bank Street, Manchester
1864	Newbigging, Thomas	Gas-Works, Pernambuco, Brazil
1872	Niven, George Henry	Gas-Works, Skelmanthorpe, near Huddersfield

	NAME.	ADDRESS.
1867	Niven, John	Gas-Works, Clayton, near Bradford
1870	Niven, Robert James	Gas-Works, Kettering, Northamptonshire
1870	North, William.	Gas-Works, Stourbridge
1872	Ogden, Samuel Robinson.. ..	Leeds Corporation Gas-Works, New Wortley, Leeds
1866	Ohren, John	Gas-Works, Rio de Janeiro, Brazil
1864	Ohren, Magnus (*Past Acting President*)	Crystal Palace District Gas Company, Bell Green, Lower Sydenham, S.E.
1870	Osborn, George Holmes	Gas-Works, Bromley, Kent
1866	Osmond, William	Gas-Works, Dorchester
1865	Otty, W. L.	Corporation Gas-Works, Limerick
1872	Ozanne, Ernest..	Gas-Works, Guernsey
1870	Padfield, William Albert	Gas-Office, Exe Island, Exeter
1865	Parkinson, G. J.	Gas Office, Union Street, Birmingham
1868	Parlby, William	Gas-Works, Aylesbury
1872	Parsons, Matthew J.	Gas-Works, Carnarvon
1872	Parsons, William	Gas-Works, Atherstone
1864	Paterson, James	Gas-Works, Warrington
1870	Paterson, Robert Ormiston ..	Gas-Works, Cheltenham
1868	Pearson, Thomas	Gas-Works, Portland
1869	Penny, Alfred	21, Wharf Road, City Road, London, N.
1867	Phelps, Joseph	Gas-Works, Marlborough, Wilts
1869	Phillips, Arthur Frederick ..	Gas-Works, St. Albans
1872	Philps, Walter..	High Street, Dorking, Surrey
1871	Philpots, Frederick	Gas-Works, Dursley, Gloucestershire
1871	Pierson, Henry Samuel	Matilda Cottage, Chatham Road, Wandsworth Common
1869	Plumbe, William A...	Gas-Works, Sutton-in-Ashfield, Notts
1870	Pontifex, Samuel	Audley House, Somerset Road, New Barnet, N.
1867	Porter, J. T. B...	Gas Engineer, Lincoln
1869	Prescott, William	Gas-Works, Prescot, Lancashire
1868	Price, Edward	Gas-Works, Hampton Wick, London, S.W.
1872	Price, James	Gas-Works, Sutton, near Chester
1871	Price, Robert	Gas-Works, Llandudno, North Wales
1870	Pritchard, William	Gas-Works, St. Helen's, Lancashire
1869	Rafarel, William Claude.. ..	Gas-Works, Barnstaple, Devon
1866	Rafferty, Thomas	Out-door Superintendent, Gas Office, Albert Chambers, Albert Sq., Manchester
1871	Randall, James..	Gas Office, Tottenham, N.

	Name.	Address.
1868	Read, Charles	
1866	Read, John	Gas Office, Tunbridge Wells
1868	Reed, Joseph	Gas-Works, Newport, Isle of Wight
1869	Reid, John	Gas Engineer, Midland Railway, Derby
1868	Rich, James	Gas-Works, Devonport
1865	Robinson, Chas. R.	Gas-Works, Coventry
1866	Robinson, C. S...	Gas-Works, Leicester
1866	Robinson, Geo. A.	Gas-Works, Leicester
1864	Robinson, James Henry	Gas-Works, Leamington
1864	Robinson, W. L.	Gas-Works, Coventry
1870	Rowan, John	Gas-Works, Colchester
1864	Rowe, John	
1869	Romans, William	1, Walbrook, London, E.C.
1867	Russell, John	Gas-Works, Uxbridge
1870	Scott, George	Gas-Works, Tunbridge Wells
1870	Severs, George	Gas-Works, Birstall, near Leeds
1872	Sheppard, Robert	Gas-Works, Horsham, Sussex
1864	Shimeld, William	Gas-Works, Dundalk, Ireland
1864	Simpson, P.	Gas-Works, Rugby
1868	Slip, William Henry	Gas-Works, Slough, Bucks.
1866	Smedley, Geo.	Gas-Works, Buxton, Derbyshire
1866	Smith, Edward	Gas-Works, Droitwich
1870	Smith, Henry Wall	Gas-Works, Seaham Harbour
1869	Smith, Joseph Richard	Gas-Works, Padiham
1870	Smith, Thomas	Gas-Works, Wigan
1864	Smith, Jun., William	Gas-Works, Hyde
1866	Somerville, John (*Mem. of Com.*)	Alliance Gas-Works, Great Brunswick Street, Dublin
1868	Spice, Robert P.	21, Parliament Street, London, S.W.
1871	Stelfox, Jun., James	Gas-Works, Belfast
1867	Stephenson, H. P.	8, St. Mary Axe, London, E.C.
1867	Stevens, Frederick James ..	19, Southwark Bridge Road, London, S.E.
1867	Stevenson, Geo. Wilson	19, Great George Street, Westminster, S.W.
1867	Stevenson, John	Gas Office, Grafton Street, Dublin
1871	Still, Alfred H...	Gas-Works, Cork
1864	Stiven, William	Gas-Works, Inverness
1867	Stone, Thomas	Gas-Works, Weymouth
1865	Storer, John	Gas-Works, Stafford
1872	Stormouth, Thomas	Gas-Works, Letterkenny, Ireland
1866	Stout, William	Gas-Works, Boston

	Name.	Address.
1864	Strachan, John..	
1870	Studholm, Shadrach..	Gas-Works, Whitehaven
1872	Swallow, David	Gas-Works, Bradford
1868	Syms, William	Gas-Works, Rochester
1864	Tadman, C.	Gas-Works, Norwich
1872	Tallentire, Thomas	Gas-Works, Lisburn, Ireland
1867	Taylor, Charles..	Gas-Works, Derby
1867	Thompson, John W...	Gas-Works, Yeadon, near Leeds
1864	Throsby, W. P...	Gas-Works, Lincoln
1872	Tidman, Edward	Gas-Works, North Ormsby, Yorkshire
1869	Tindall, John	Gas-Works, Walsall
1869	Tinney, William Upton	Gas-Works, Winchester
1872	Travers, Thomas	Gas-Works, Cork, Ireland
1870	Trewby, George Careless.. ..	Gas-Works, Beckton, North Woolwich, E.
1867	Trewhitt, Thos.	Gas-Works, West Hartlepool
1868	Turney, Ambrose R.	
1869	Upward, Alfred (*Mem. of Com.*)	11, Great Queen Street, Westminster, S.W.
1872	Valon, William A.	Gas-Works, Ramsgate
1870	Vanheson, George B.	Gas-Works, Rochester
1869	Varley, Thomas	Gas-Works, Colne, Lancashire
1865	Veevers, Harrison (*Member of Committee*)	Gas-Works, Bolton
1869	Venner, Bartholomew Gay ..	Gas-Works, Eton, Bucks
1864	Wadeson, James	Gas-Works, Windsor
1866	Warner, W. J.	Gas-Works, South Shields
1871	Warsop, Henry	Gas-Works, East Croft, Nottingham
1866	Wates, Percy J.	Phœnix Gas-Works, Greenwich, S.E.
1872	Watson, James..	Crystal Palace District Gas-Works, Bell Green, Lower Sydenham, S.E.
1872	Watson, Robert..	Gas-Works, Morpeth
1872	Watson, William Clarke	Gas-Works, Kingston-on-Thames, Surrey
1869	Waugh, John	
1872	Wells, Henry F.	Gas-Works, Tredegar, Monmouthshire
1869	West, John	Gas-Works, Maidstone
1871	Whitaker, William Butler ..	Gas-Works, Belper, Derbyshire
1865	White, Edward (*Past Acting President*)	Gas-Works, Windsor Street, Birmingham
1868	White, T. W. R.	Gas-Works, Sherborne
1872	White, William	Equitable Gas-Works, Woolwich

	Name.	Address.
1872	White, William..	Gas-Works, Abersychan, near Pontypool, Monmouthshire
1871	Whitehead, William Swallow .	11, Drewton Street, Bradford
1869	Wilkinson, Peter Haines	Gas Office, James Street, Harrogate
1868	Williams, Alfred	64, Bankside, London, S.E.
1864	Willis, W. H.	Gas-Works, Great Yarmouth
1871	Wilson, John	Gas-Works, Abingdon, Berks
1870	Wilson, William Purvis	19, Northumberland Street, Strand, London, W.C.
1871	Wilton, John	Gas-Works, Silvertown, North Woolwich, E.
1865	Wood, Alfred H.	Gas-Works, Hastings
1864	Wood, Joseph (*Vice-President*)	Gas-Works, Bury
1866	Wood, William	Gas Office, Cambridge
1865	Woodall, Corbett	Phœnix Gas-Works, Vauxhall, London, S.W.
1865	Woodall, Henry	Gas-Works, Longport
1872	Woodward, John	Gas-Works, Spalding, Lincolnshire
1870	Wright, Charles	Gas-Works, Saffron Walden, Essex
1864	Wright, William	Alexandra Road, Shipley, near Leeds
1868	Wright, William	Gas-Works, Lewes
1871	Wroe, John	Gas-Works, Rhyl, Flint
1864	Young, Alfred	
1869	Young, John	Gas-Works, Kingston-upon-Hull

(*Number of Ordinary Members*, 391.)

Extra-Ordinary Members.

	Name.	Address.
1872	Aird, Joseph	Wellington Tube-Works, Great Bridge, Tipton
1868	Aird, Jun., John	Belvedere Road, Lambeth, London, S.E.
1872	Andrews, William Ward ..	Gas-Meter Company's Works, 238, Kingsland Road, London, E.
1872	Braddock, Jun., Joseph	72, Windsor Road, Oldham
1868	Cowen, John A.	Blaydon-on-Tyne
1869	Cutler, Samuel	Providence Iron-Works, Millwall, Lond., E.
1870	Donaldson, A.	Buccleuch Street Works, Edinburgh
1870	Fraser, William	Inverkeithing

	Name.	Address.
1865	Giles, Alfred	Rugeley
1870	Horsley, Charles . .	22, Wharf Road, City Road, London, N.
1871	Laidlaw, David..	Gas Engineer, Glasgow
1872	M'Dougall, James Thomas ..	158, Leadenhall Street, London, E.C.
1872	M'Dougall, Jun., Alexander ..	68, Port Street, Manchester
1872	Manwaring, Joseph	101, Cannon Street, London, E.C.
1871	O'Neill, John W.	Lombard Exchange, London, E.C.
1864	Owst-Atkinson, A.	Quay Chambers, Parliament Street, Hull
1870	Payne, George	Messrs. Simpson, Payne, & Co.'s Chemical Works, Millwall, London, E.
1872	Peebles, D. Bruce	Fountainbridge Works, Edinburgh
1870	Pollard, James William	9, Mincing Lane, London, E.C.
1866	Potter, Addison	Willington Quay, near Newcastle-upon-Tyne
1870	Robertson, George	106, Leadenhall Street, London, E.C.
1859	Spence, John Berger	Earlington House, near Manchester
1870	Thorneloe, George	34, London Wall, London, E.C.
1868	Walker, William Thomas ..	Donnington, near Newport, Salop, and 8, Finsbury Circus, London, E.C.
1870	Waller, George	Phœnix Works, Holland Street, Southwark, London, S.E.
1872	Willey, Henry Frederick ..	4, Longbrook Street, Exeter
1870	Williams, Frederick..	75, Mark Lane, London, E.C.

(*Number of Extra-Ordinary Members*, 27.)

Total number of Members, 425.

LIST OF MEMBERS,

Arranged in the Alphabetical Order of the Towns they reside in.

A * prefixed to the name denotes an Honorary Member.
A † „ „ Extra-Ordinary Member.

ABERGAVENNY, Mon.	Samuel Cross, Gas-Works.
ABERSYCHAN, Mon.	William White, Gas-Works.
ABINGDON, Berks.	John Wilson, Gas-Works.
ACCRINGTON, Lancashire	William Barratt, Gas-Works.
ARBROATH, Forfar, N.B.	Robert Brown, Gas-Works.
ASHFORD, Kent..	George Berry, Gas-Works.
ASHTON-UNDER-LYNE	Isaac Kelsall, Gas-Works.
ATHERSTONE, Warwickshire	William Parsons, Gas-Works.
AYLESBURY, Bucks...	William Parlby, Gas-Works.
AYR	Laurence Hislop, Gas-Works.
BACUP, Lancashire	William Blackledge, Gas-Works.
BALDOCK, Herts	James Gilbert Dear, Gas-Works.
BALLYMENA, Co. Antrim, Ireland ..	John Hale, Gas Works.
BANBURY, Oxon.	W. R. Cooper, Gas-Works.
BARNET	Thomas Douglas, Gas-Works.
BARNSLEY, Yorkshire	John Hutchinson (*Mem. of Com.*), Gas-Works.
„ „	Walter W. Hutchinson, Gas-Works.
„ „	Charles Henry Hutchinson, New Gas-Works.
BARNSTAPLE, Devon..	William Claude Rafarel, Gas-Works.
BATH	George Helps, Gas-Works.
„	Thomas Anderson, Gas-Works.
„	Daniel Helps, Gas-Works.
BECKTON, North Woolwich	George Careless Trewby, Gas-Works.
„	Frederick Beale, Gas-Works.

Belfast, Co. Antrim, Ireland ..	James Stelfox, jun.
Belper, Derbyshire	William Butler Whitaker, Gas-Works.
Beverley, Yorkshire	John Foxall, Gas-Works.
Birmingham	Edward White (*Past Acting President*), Gas-Works, Windsor Street.
"	G. J. Parkinson, Gas Office, Union Street.
"	John Methven, Gas-Works, Windsor Street.
Birstall, near Leeds	George Severs, Gas-Works.
Blackburn, Lancashire	Orlando Brothers, Gas-Works.
Blaydon-on-Tyne	†John A. Cowen.
Blyth, Northumberland	James Eadington, Gas-Works.
Bolton, Lancashire	Harrison Veevers (*Mem. of Com.*), Gas-Works.
Boston, Lincolnshire	William Stout, Gas-Works.
Bradford, Yorkshire	David Swallow, Gas-Works.
" "	William Swallow Whitehead, 11, Drewton Street.
Bridgnorth, Salop	Robert Gill, Gas-Works.
Bridgwater, Somerset	James Hughes Cornish, Gas-Works.
Bridport, Dorsetshire	James Lowe, Gas-Works.
Bristol	Walter Fiddes, Gas-Works.
Broad Green, near Liverpool ..	George Harding.
Bromley, Kent	George Holmes Osborne, Gas-Works.
Brymbo, Denbigh	David Clark, Gas-Works.
Burnley, Lancashire	S. P. Leather (*Auditor*), Gas-Works.
Burton-on-Trent, Staffordshire ..	John Mudie, Gas-Works.
Bury, Lancashire	Joseph Wood (*Vice-President*), Gas-Works.
Bury St. Edmund's, Suffolk	T. H Methven, Gas-Works.
Buxton, Derbyshire	Geo. Smedley, Gas-Works.
" "	E. E. Jones, Gas-Works.
Calcutta	James Blackburn, Gas-Works.
"	Francis William Brothers, Gas-Works.
Camborne, Cornwall	William Bailey, Gas-Works.
Cambridge	William Wood, Gas Works.
Canterbury, Kent	Thomas May, Gas-Works.
Cardiff, Glamorganshire	Henry Bowen, Gas-Works.
Carlisle, Cumberland	Joseph Hepworth, Gas-Works.
Carnarvon	Matthew J. Parsons, Gas-Works.
Carshalton, Surrey	Robert Good, Gas-Works.
Caterham Valley, Surrey	Frank Frederick Ferrand, Gas-Works.
Chale, Isle of Wight	Augustus F. Livesay.
Cheltenham, Gloucestershire ..	Robert Ormiston Paterson, Gas-Works.

CHICHESTER, Sussex	Robert Church, Gas-Works.
CIRENCESTER, Gloucestershire.. ..	A. M. Murphy, Gas-Works.
CLAYTON, near Bradford	John Niven, Gas-Works.
CLITHEROE, Lancashire	William Miles, Gas-Works.
COLCHESTER, Essex	John Rowan, Gas-Works.
COLNE Lancashire	Thomas Varley, Gas-Works.
COLOMBO, Ceylon	John Hegarty, Gas-Works.
CONGLETON, Cheshire	Thomas Henry Daniel, Gas-Works.
CORK, Ireland	Denny Lane, 72, South Mall.
" "	A. H. Still, Gas-Works.
" "	Thomas Travers, Gas-Works.
COVENTRY, Warwickshire	Chas. R. Robinson, Gas-Works.
" "	W. L. Robinson. Gas-Works.
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